



PROGRESS REPORT

STANDARDIZATION ROADMAP FOR ELECTRIC VEHICLES

VERSION 2.0



Prepared by the
Electric Vehicles
Standards Panel
of the American National
Standards Institute

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Introduction

In January 2014, the American National Standards Institute Electric Vehicles Standards Panel (ANSI EVSP) resumed work to assess existing and needed standards and conformity assessment solutions to enable electric vehicles and charging infrastructure to be deployed throughout the United States. This report assesses progress to address the standardization gaps identified in the [Standardization Roadmap for Electric Vehicles – Version 2.0 \(May 2013\)](#) (“roadmap”).¹ It also includes updates on significant standardization activity related to the issues identified in the roadmap. The [ANSI EVSP Roadmap Standards Compendium](#),² a searchable spreadsheet of relevant electric vehicle standards, also has been updated separately.

Accordingly, readers of this report should be familiar with the roadmap version 2.0: why and how it was developed and promoted, applicable parameters and definitions, the key organizations involved in U.S. electric vehicle standardization, why issues were deemed important, what standards apply, and the basis for any identified gaps. A gap is where there is a significant issue of concern that is not addressed by existing standards, codes, regulations, or conformance programs.

For ease of comparison, this report follows the numbering in section 4 of the roadmap. Text is only provided where it is substantially new or revised from the roadmap text. If aspects of an issue are not addressed, it means that no new or different information was provided. All roadmap gap statements and recommendations have been reiterated or modified as appropriate and an update is provided in each case on the status of work.

¹ http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_May_2013.pdf

² http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_Standards_Compendium.xls

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Summary of Activity Since Publication of Roadmap Version 2.0

Summary of Gap Analysis Changes

- 61 issue areas are explored; in 13 cases, no gap was found
- 4 new gaps are identified
- 3 gaps were previously reported closed in version 2.0
- 1 gap previously reported closed has been re-opened
- 1 additional gap has been closed
- A total of 44 gaps are open; of these:
 - 28 are near-term priorities (should be addressed in 0-2 years)
 - 15 are mid-term priorities (should be addressed in 2-5 years)
 - 1 is a long-term priority (should be addressed in 5+ years)

New Gaps

- A new gap on “Crash Test Lab Safety Guidelines” (4.1.1.7) has been added with the recommendation to complete work on SAE J3040.
- A new gap on “Coordination of Wireless Charging Communication Standards” (4.2.1.1) has been added with the recommendation that organizations developing standards, guidelines or use cases related to wireless charging communications should coordinate their activities.
- A new gap on “Certification Standards for Mobile Inverters” (4.2.1.5) has been added with the recommendation to create SAE J3072 to ensure an EV on-board inverter system can be safely interconnected to the electric power system, and to modify UL 9741 to serve as the standard for an EVSE which is interoperable with an EV inverter system which conforms to SAE J3072.
- A new gap on “Mobile Inverters: Interconnection Agreements” (4.2.1.5) has been added with the recommendation to coordinate an approach with utilities and federal and state government agencies on how an EV with an on-board inverter can be approved to discharge at a specific EVSE location.

Substantially Revised Gaps

- A gap on “Vehicle as Supply / Reverse Power Flow” (4.2.1.5) has been revised.

Previously Closed Gaps

- A gap on “Power Quality” (4.2.1.3) previously reported closed has been re-opened pending publication of SAE J2894/2.

Closed Gaps

- A gap on “Packaging and Transport of Waste Batteries” (4.1.1.4) has been closed.

Other Notable Activity – Power Levels and Batteries

- Work has been re-started on the power rating standards SAE J2907 and J2908.
- The DOT/NHTSA-funded SAE Cooperative Research Project (CRP) to Develop Repeatable Safety Performance Test Procedures for Rechargeable Energy Storage Systems (RESS) should conclude by the end of November 2014. A report is expected in the Spring of 2015.
- SAE J2984, Identification of Transportation Battery Systems for Recycling Recommended Practice, has been published.
- SAE J2974, Technical Information Report on Automotive Battery Recycling, is out for ballot.
- UL 1974 on secondary life applications for batteries has been proposed.

Other Notable Activity – Charging Systems / EVSE Interoperability

- Under 4.2.1.1, new sub-sections on *Communication in support of wireless power transfer and Electromagnetic compatibility (EMC) in relation to wireless charging* have been added.
- Two projects under development are SAE J3068, EV Power Transfer using Three-phase Capable Coupler, and IEEE P2030.1.1, Standard Technical Specification of a DC Quick Charger for Use with Electric Vehicles.
- IEC 61851-23 and IEC 61851-24 were published dealing with DC EV charging stations and digital communication for DC charging.
- IEC 62196-1 and IEC 62196-3 were published on general and dimensional requirements for EV couplers.
 - o The SAE J1772TM combo coupler configuration is included in IEC 62916-3.
 - o Differences exist between the SAE and IEC standards in terms of allowing AC and DC charging to occur on the same contact pins.
- SAE J2953, parts 1 and 2, has been published on requirements and test procedures for interoperability between a PEV and EVSE.

Other Notable Activity – Communications for EV Charging

- Under 4.2.2.1, a new sub-section *SAE Task Force Activity: PEV/EVSE Communications* has been added. Several standards of the SAE task force have been published or are nearing publication.
- ISO 15118, parts 1 and 2, on vehicle to grid communication interfaces also has been published.
- Under Section 4.2.2.2, the sub-section *Locating and Reserving Public Charging Stations (EVSE), and Roaming*, has been substantially expanded. Multiple Standards Development Organizations (SDOs) are working on standardization of locating and reserving charging stations and inter-provider protocols for various aspects of EV roaming (NEMA et al.).

Other Notable Activity – Communication and Measurement of EV Energy Consumption

- NEMA is continuing to develop a guide for EVSE embedded metering and communication.
- The NIST U.S. National Work Group on Measuring Systems for Electric Vehicle Fueling and Submetering (USNWG EVF&S) is continuing work on proposed requirements for commercial electricity-measuring devices.
- A Uniform Regulation for the Method of Sale of Electricity Sold as a Vehicle Fuel was adopted by the National Conference on Weights and Measures (NCWM) and published in NIST Handbook 130.
- The USNWG EVF&S is developing a draft device code for review, possible national adoption, and subsequent publication in NIST HB 44, as well as field test equipment and test procedures.
- The SGIP PAP22 is coordinating with these activities.

Other Notable Activity – Privacy, Security, Customer to PEV Communications

- Cyber Security and Data Privacy
- Work on SAE J2931/7 has been re-started.
- ISO 15118-1 has been published.
- The SGIP and NIST are reviewing comments on Draft NISTIR 7628 Rev 1.
- Customer to PEV Communications
- Section 4.2.2.5 has been re-named *Customer to PEV Communications*. SAE J2836/5™ will identify use cases for customer convenience functions and network synchronization.

Other Notable Activity – Installation Issues

- There are references to the National Electrical Code® (NEC®) throughout the roadmap. The 2014 version of the NEC® was published in September 2013. Proposed changes for the 2017 edition of the NEC® are being accepted through the first Friday of November 2014.
- The National Electrical Code® (NEC®) Article 625 was amended that when an automatic load management system is used, the maximum load on a feeder or service shall be the maximum load permitted by the automatic load management system.
- Proposals were approved by the ICC A117.1 committee for technical criteria on how to make an EV charging station accessible.
- Modifications were made to Article 625 of the NEC® to define a cable management system and related to the height of cables; work is in progress to address output cable ampacity.

Other Notable Activity – Fire Protection and Stranded Energy

- The NFPA Fire Protection Research Foundation published a report on best practices for emergency response to incidents involving EV battery hazards.
- The NHTSA and Argonne NL project to develop a universal diagnostic and battery discharge system (including methods of diagnosing / extracting stranded energy) should be completed by November 2014 with a report due in the Spring of 2015; Sandia NL and Idaho NL are also working on a diagnostic strategy.
- Not much progress has been made on SAE J3009 on stranded energy but the committee is restarting with a new chair.

Other Notable Activity – Workforce Training

- The DOE clean cities program issued a funding opportunity announcement that includes alternative fuel training for emergency first responders, public safety officials, and critical service providers.
- The DOE clean cities program is also working on a zoning codes and ordinances website for community, municipal and state planning officials.
- NFPA received a DHS grant to develop training modules for EV and hybrid commercial trucks, buses, and medium sized delivery vehicles.
- NFPA is expanding its first responder training to law enforcement and EMS including best practices on stranded energy.
- UL is offering training related to EV infrastructure installation.

4. Gap Analysis of Standards, Codes, Regulations, Conformance Programs and Harmonization Efforts

4.1 Vehicle Domain

Terminology

- SAE J1715, Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology, published in 2008, is an SAE Information Report providing commonly used terminology established by the technical community involved with writing practices and information reports for HEVs and EVs. It has been published in July 2014. The new version is designated part 1.
- SAE J1715/2, Battery Terminology, was published in July 2013. This SAE information Report contains definitions for energy storage systems and battery terminology.

Partial Gap: Terminology. There is a need for consistency with respect to electric vehicle terminology.

Recommendation: Complete work to revise SAE J1715. **Priority:** Mid-term. **Potential Developer:** SAE, ISO. **Grid Related:** No. **Status of Progress:** Green. **Update:** As noted, SAE J1715 has been divided into two parts which have been published.

4.1.1 Energy Storage Systems (EVs)

4.1.1.1 Power Rating Methods

Two standards are under development to address power rating methods for electric vehicles:

- SAE J2907, Hybrid Motor Ratings, which will support ongoing efforts with J2908 to define and establish unified requirements for measuring hybrid and plug in hybrid electric power levels.
- SAE J2908, Hybrid Electric Powertrain Power Test Methods and Definitions, which will provide recommended test options for measuring and defining total powertrain power and electric power levels for hybrid electric vehicles (including plug-in hybrids).

Gap: Power rating methods. Standards for electric vehicle power rating methods are still in development.

Recommendation: Complete work to develop SAE J2907 and J2908. **Priority:** Mid-term. **Potential Developer:** SAE. **Grid Related:** No. **Status of Progress:** Green. **Update:** It was noted in roadmap version 2.0 that standards for electric vehicle power rating methods had been canceled because of resource issues and would be re-opened later. As noted, work on the power rating method standards SAE J2907 and J2908 has been restarted.

4.1.1.2 Battery Safety

Two issues and gaps were identified in roadmap version 2.0 as described below.

Functional safety in the charging system

The DOT/NHTSA-funded SAE Cooperative Research Project (CRP) to Develop Repeatable Safety Performance Test Procedures for Rechargeable Energy Storage Systems (RESS) is ongoing. The project, originally scheduled to conclude by August 31, 2014, has been extended by 90 days. The following test procedures are being developed to address HEV/PEV/PHEV battery system abuse and environmental conditions:

- Isolation
- Vibration
- Thermal Shock
- External Short Circuit Protection – System Level
- Overcharge Protection – System Level
- Over Discharge Protection – System Level
- Over Temperature Protection – System Level
- Under Temperature Protection – System Level
- Fire Resistance
- Pack Level Thermal Propagation
- Water Intrusion Test
- Battery Management System - Single & Multiple System Failure Protection*

*Note: Battery Management System (BMS) - Single & Multiple System Failure Protection addresses component level failures in the BMS. Also, SAE J2953 on EV Charging Interoperability has elements which address functional safety in the charging system.

NHTSA's intent is to release the details of these test procedures to the public sometime in the Spring of 2015.

Gap: Functional safety in the charging system. Potential faults in the charging system, both on-board and off-board, are the subject of NHTSA sponsored research and may need to be addressed in future rulemaking and/or standardization.

Recommendation: Future NHTSA rulemaking and/or revisions to SAE J2929 should consider the results of the DOT/NHTSA-funded SAE Cooperative Research Project with respect to fault events in the charging system which could lead to overcharging. **Priority:** Near-term. **Potential Developer:** NHTSA, SAE. **Grid Related:** No. **Status of Progress:** Green. **Update:** As noted in the text, work is underway in the CRP to address this issue.

Delayed battery overheating events

Gap: **Delayed battery overheating events.** The issue of delayed battery overheating needs to be addressed.

Recommendation: Address the issue of delayed battery overheating events in future rulemaking and/or revisions of SAE J2929 based on the results of the DOT/NHTSA-funded SAE Cooperative Research Project (CRP). **Priority:** Near-term. **Potential Developer:** NHTSA, SAE. **Grid Related:** No. **Status of Progress:** Green. **Update:** Work is underway in the CRP to address this issue.

4.1.1.3 Battery Testing – Performance and Durability

Gap: **Battery performance parameters and durability testing.** There is a need for further work on EV battery performance parameters and environmental durability test requirements.

Recommendation: Complete work on SAE J1798 and if possible consider harmonization with ISO 12405-2. **Priority:** Mid-term. **Potential Developer:** SAE, ISO. **Grid Related:** No. **Status of Progress:** Yellow. **Update:** No change. There is not a lot of progress to date on SAE J1798.

4.1.1.4 Battery Storage, Packaging, Transport and Handling

Battery Storage

The June 2013 NFPA Fire Protection Research Foundation report titled *Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results* recommended that NFPA should consider updating interim guidelines and responder training to not store a damaged or burned Li-ion HV battery in or within 50 feet of a structure, another vehicle, or combustible materials until the battery can be safely discharged, if possible, in accordance with vehicle manufacturer procedures by trained and qualified staff. Adopting guidance in SAE J2990 on Damaged EV Storage Isolation Recommendations is also mentioned in the report. [See also section 4.3.1.4.]

There are two items on the work programme of IEC/TC 69 which also may deal with aspects of this issue:

- IEC 62840-1 Ed.1.0, Electric vehicle battery swap system Part 1: System description and general requirements, targeted for publication in April 2015

- IEC 62840-2 Ed. 1.0, Electric Vehicle Battery Swap System - Part 2: Safety requirements, targeted for publication in mid-2016.

Gap: Safe storage of lithium-ion batteries. At present, there are no published standards addressing the safe storage of lithium-ion batteries specifically, whether at warehouses, repair garages, recovered vehicle storage lots, auto salvage yards, or battery exchange locations.

Recommendation: A standard on safe storage practices for EV batteries must be developed, addressing both new and waste batteries and the wide range of storage situations that may exist, including when the batteries are separated from their host vehicle. **Priority:** Near-term. **Potential Developer:** SAE, NFPA, ICC, IEC/TC 69. **Grid Related:** No. **Status of Progress:** Green. **Update:** Work by the NFPA Fire Protection Research Foundation and IEC/TC 69 is noted in the text.

Battery Packaging, Transport and Handling

A proposal by the Portable Rechargeable Battery Association (PRBA) and the International Association for the Promotion and Management of Portable Rechargeable Batteries (RECHARGE) on waste Li batteries was adopted by the United Nations in December 2012. The new regulations will go into effect internationally on January 1, 2015.

Gap: Packaging and transport of waste batteries. Current standards and regulations do not adequately cover transportation aspects of *waste* batteries (damaged, aged, sent for repair, end-of-life) in terms of packaging, loading limitations, combination with other dangerous goods on same transport, etc.

Recommendation: There is a need for a harmonized approach toward communication, labeling, packaging restrictions, and criteria for determining when a battery is waste. **Priority:** Near-term. **Potential Developer:** UN SCOE on the Transport of Dangerous Goods, ISO/TC 22/SC21, SAE or UL. **Grid Related:** No. **Status of Progress:** Closed. **Update:** With the approval of new UN regulations, this gap is now closed.

Gap: Packaging and transport of batteries to workshops or battery swapping stations. Unloading a battery in a battery swapping station is extremely challenging with the original packaging used for dangerous goods transportation. There is a need for standards for intermediate packaging to cover transport to battery swapping stations.

Recommendation: Intermediate packaging is required between the import location of the battery and battery swapping stations and needs to be standardized around geometry, safety and matching to UN packaging requirements. **Priority:** Mid-term. **Potential Developer:** ISO/TC 22/SC21, IEC/TC 69, SAE or UL. **Grid Related:** No. **Status of Progress:** Unknown. **Update:** IEC 62840, Parts 1 and 2, under development, may deal with aspects of this issue.

4.1.1.5 Battery Recycling

Relevant projects are:

- SAE J2974, Technical Information Report on Automotive Battery Recycling. SAE is working on incorporating some recommendations on design for recyclability. This document is out for voting in October 2014.
- SAE J2984, Identification of Transportation Battery Systems for Recycling Recommended Practice. Revision 2 of this document was published on August 5, 2013.

Gap: Battery recycling. Standards are needed in relation to EV (li-ion) battery recycling.

Recommendation: Complete work on SAE J2974 and J2984. EV (li-ion) battery recycling standards are desirable to address the calculation method toward recycling efficiency and recovery rates based on an agreed unit (possibly weight) and/or life-cycle assessment tools, including energy recovery. **Priority:** Near-term. **Potential Developer:** SAE, IEC. **Grid Related:** No. **Status of Progress:** Green. **Update:** Relevant work by SAE is noted in the text.

4.1.1.6 Battery Secondary Uses

A new project, UL 1974, dealing with secondary life applications for batteries has been proposed for development as an American National Standard.

Gap: Battery secondary uses. There is a need for standards to address battery second life applications for grid storage and other uses.

Recommendation: Explore the development of standards for battery secondary uses, addressing such issues as safety and performance testing for intended applications, grid connection/communication interfaces, identification of parts/components that can be removed from the pack without destroying it, etc. **Priority:** Mid-term. **Potential Developer:** SAE, UL. **Grid Related:** No. **Status of Progress:** Green. **Update:** UL work is noted in the text. No new information was provided on SAE activity.

4.1.1.7 Crash Tests / Safety

The SAE EV Crash Test Safety Procedures Task Force is developing an information report SAE J3040, EV Crash Testing Safety Guidelines. A recommended practice may be published later on.

Gap: Crash Test Lab Safety Guidelines. There is a need for laboratory guidance and instruction to help mitigate the risks to personnel, equipment, and facilities that may exist in the event of catastrophic failure of the battery system.

Recommendation: Complete work to develop an Information Report (SAE J3040) that can be readily available to any crash test laboratory conducting, or planning to conduct, full scale crash tests on

EVs/HEVs. **Priority:** Near-term. **Potential Developer:** SAE. **Grid Related:** No. **Status of Progress:** New Gap /Green.

4.1.2 Vehicle Components

4.1.2.1 Internal High Voltage Cables, On-Board Wiring, Component Ratings and Charging Accessories

No new information has been provided with respect to this issue.

4.1.2.2 Vehicle Diagnostics – Emissions

The California Air Resources Board Low Emission Vehicle (LEV) III regulations (final reg. finalized July 31, 2013) contain updates to the OBD regulations (Title 13 Cal Code of Reg, Sections 1968.2 and 1968.5) which include new provisions to deal with electric vehicles.³

The California Air Resources Board is working on changes to its OBD II regulations that would, among other things, include more detailed monitoring requirements for both hybrid-electric and plug-in hybrid electric vehicles (see workshop notice published Sep. 19, 2014).⁴ CARB plans to publish its proposal for public comment in April 2015 and seek Board approval in May 2015.

4.1.2.3 Audible Warning Systems

SAE J2889-1 was last issued May 14, 2012. ISO 16254, a technically equivalent document, is at the draft international standard (DIS) ballot stage. SAE J2889-1 will be revised taking into account comments on the ISO 16254 ballot. The goal would be to have a harmonized document that can inform the NHTSA regulation now scheduled to be finalized by July 2015. The EU also has voted to have a quiet car regulation finalized. WP.29's work on a quiet car GTR also continues.

Partial Gap: Audible warning systems. Creation of the NHTSA safety standard and compliance with it will effectively close any gap with respect to audible warning systems for electric vehicles sold in the U.S. market. Ongoing standards work in SAE and ISO, and in WP.29 with respect to the development of a Global Technical Regulation would provide a means for international harmonization around this issue.

Recommendation: Continue work on safety standards to address EV sound emission and measurement.

Priority: Near-term. **Potential Developer:** SAE, ISO, NHTSA, WP.29. **Grid Related:** No. **Status of Progress:** Green. **Update:** Work continues as noted in the text.

³ <http://www.arb.ca.gov/msprog/obdprog/obdregs.htm>

⁴ <http://www.arb.ca.gov/msprog/mailouts/ecars1407/ecars1407.pdf>

4.1.3 Vehicle User Interface

4.1.3.1 Graphical Symbols

Gap: Graphical symbols for electric vehicles. Standards for graphical symbols for electric vehicles are needed to communicate important information to the driver such as state of charge, failure or normal system operation which can be understood regardless of the driver's language.

Recommendation: Develop EV graphical symbols standards to communicate information to the driver.

Priority: Long-term. **Potential Developer:** SAE, NHTSA, ISO, IEC. **Grid Related:** No. **Status of Progress:** Not started. **Update:** None provided.

4.1.3.2 Telematics – Driver Distraction

On April 26, 2013, NHTSA issued its Phase 1 Driver Distraction Guidelines⁵ which are intended to promote safety by discouraging the introduction of excessively distracting devices in vehicles. The Phase 1 Guidelines (applicable to EVs and other types of light duty vehicles) cover original equipment (OE) in-vehicle (i.e., integrated) electronic devices that are operated by the driver through visual-manual means (i.e., the driver looks at a device, manipulates a device-related control with his or her hand, and/or watches for visual feedback from the device). NHTSA issued a Federal Register notice on September 16, 2014⁶ to clarify the Phase 1 guidelines with respect to the following: 1) determination of the downward viewing angle, 2) the ordering of test trials when multiple tasks are tested, and 3) the maximum allowable number of eye glances longer than 2.0 seconds.

NHTSA's Phase 2 guidelines (slated to be proposed in late 2014) will apply to portable and aftermarket devices that are operated through visual-manual means and will be based on the same general principles as the phase 1 guidelines. Phase 3 Guidelines (to be developed after the Phase 2 guidelines are finalized) will address voice-activated systems.

4.1.3.3 Fuel Efficiency, Emissions and Labeling

No new information has been provided with respect to this issue.

⁵<https://www.federalregister.gov/articles/2013/04/26/2013-09883/visual-manual-nhtsa-driver-distraction-guidelines-for-in-vehicle-electronic-devices>

⁶<https://www.federalregister.gov/articles/2014/09/16/2014-21991/visual-manual-nhtsa-driver-distraction-guidelines-for-in-vehicle-electronic-devices>

4.2 Infrastructure Domain

4.2.1 Charging Systems

4.2.1.1 Wireless Charging

SAE J2954, Wireless Charging of Electric and Plug-in Hybrid Vehicles, is targeted to be published in 2015. This technical information report (TIR) will apply to light duty vehicles. A second document will address heavy duty vehicles.

The following standards are being developed by IEC/TC69:

- IEC 61980-1, Electric vehicle wireless power transfer (WPT) systems – Part 1: General requirements, is targeted for publication by February 2015.
- IEC 61980-2, Electric vehicle wireless power transfer (WPT) systems – Part 2: specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems, is targeted to have a committee draft (CD) available by the end of January 2015.
- IEC 61980-3, Electric vehicle wireless power transfer (WPT) systems – Part 3: specific requirements for the magnetic field power transfer systems, is targeted for publication by January 2017.

IEC 61980-3 is analogous to SAE J2954. There will be an attempt to harmonize IEC 61980-2 and SAE J2954.

ISO /TC 22/SC 21/WG1 is working on ISO PAS 19363, Electrically propelled road vehicles – Magnetic field wireless power transfer – Safety and interoperability requirements.

UL 2750 is still in development on basic safety requirements. It will not be completed until the design documents SAE J2954 and IEC 61980 are finished. There is no specific target date for publication.

IEEE has begun pre-standardization work on dynamic wireless charging. The communications requirements will be different than for stationary wireless charging.

Communications in support of wireless power transfer

In terms of communications standards for wireless power transfer, relevant work in development includes:

- IEC 61980-2

- SAE J2836/6™, Use Cases for Wireless Charging Communication for Plug-in Electric Vehicles, and SAE J2847/6, Wireless Charging Communication between Plug-in Electric Vehicles and the Utility Grid
- ISO 15118-6, Road vehicles -- Vehicle to grid communication interface -- Part 6: General information and use-case definition for wireless communication
- ISO 15118-7, Road vehicles -- Vehicle to grid communication interface -- Part 7: Network and application protocol requirements for wireless communication
- ISO 15118-8, Road vehicles -- Vehicle to grid communication interface -- Part 8: Physical layer and data link layer requirements for wireless communication

Gap: **Coordination of wireless charging communication standards.** Automotive manufacturers do not want to support three separate activities dealing with the same issue. An initiative is underway to understand how the work can be done once or divided between ISO, IEC and SAE. There is no clear cut technology solution right now.

Recommendation: Organizations developing standards, guidelines or use cases related to wireless charging communications should coordinate their activities in order to avoid duplication of effort, assure alignment, and maximize efficiency. **Priority:** Near-term. **Potential Developer:** SAE, ISO, IEC. **Grid Related:** Yes. **Status of Progress:** New Gap / Green.

Electromagnetic compatibility (EMC) in relation to wireless charging

Issues related to wireless charging of electric vehicles include EMC measurement and immunity, safety from shock, and safety from human exposure to radio frequency (rf) radiated emissions. On-board or off-board charging may create disturbances to radio services. There also may be safety concerns for people who are in or next to an electric vehicle that is being charged through wireless power transfer.

The SAE J2954 task force is speaking with the Federal Communications Commission (FCC) about EMC and the Food and Drug Administration (FDA) about emissions absorption rates. The FCC has asked the SAE J2954 task force to coordinate closely with ANSI IEEE C63.4, an emission measurement procedure (and the FCC Measurement Procedure, MP-5). Work under SAE J2954 may lead to new procedures being referenced in ANSI IEEE C63.4. The IEC is also in discussion with the FCC. IEC/TC 106 addresses human exposure aspects.

Gap: **Wireless charging.** Standards and guidelines for wireless charging are still in development.

Recommendation: Complete work on standards and guidelines for wireless charging as described above in the text. **Priority:** Near-term. **Potential Developer:** SAE, UL, IEEE, ISO, IEC. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The text has been updated to note work taking place, including communications and EMC aspects. The recommendation statement has been made general with references to specific standards removed. ISO has been added as a developer.

4.2.1.2 Battery Swapping

There are two items on the work programme of IEC/TC 69:

- IEC 62840-1 Ed.1.0, Electric vehicle battery swap system Part 1: System description and general requirements, targeted for publication in April 2015
- IEC 62840-2 Ed. 1.0, Electric Vehicle Battery Swap System - Part 2: Safety requirements, targeted for publication in mid-2016.
- In addition, SAE has a new project SAE J3073 on battery cooling.

Gap: Battery swapping – safety. Currently, there is a need to define minimum requirements for the safe operation of battery swapping stations, as deployment of battery swapping systems is currently underway in several countries around the world.

Recommendation: Complete work on IEC 62840 to define minimum requirements for the safe operation of battery swapping stations, and on SAE J3073. **Priority:** Mid-term. **Potential Developer:** IEC/TC 69, SAE.

Grid Related: No. **Status of Progress:** Green. **Update:** The text has been updated to note that the standard is in two parts. Priority level has been changed from near-term to mid-term in light of this technology's relevance to the U.S. market. SAE has been added as a potential developer given new work on battery cooling.

Gap: Battery swapping – interoperability. Standards are needed to help facilitate the penetration of battery swapping in the market. Issues to be addressed related to removable batteries include electrical interfaces, cooling integration, data transfer integration, and common mechanical and dimensional interfaces.

Recommendation: Define interoperability standards related to battery swapping. **Priority:** Mid-term.

Potential Developer: IEC/TC 69, SAE. **Grid Related:** No. **Status of Progress:** Green. **Update:** Some of the mentioned aspects of interoperability may be addressed in the IEC 62840 work that is taking place. Priority level has been changed from near-term to mid-term in light of this technology's relevance to the U.S. market. SAE has been added as a potential developer given new work on battery cooling.

4.2.1.3 Electric Vehicle Supply Equipment (EVSE)

Power Quality

A ballot on SAE J2894/2 closed at the end of September, 2014 with a favorable result.

Partial Gap: Power quality. SAE J2894/1 was published in December 2011. At the time of publication of roadmap version 2.0, SAE J2894, Part 2, was still in development.

Recommendation: Complete work on SAE J2894, Part 2. **Priority:** Near-term. **Potential Developer:** SAE. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The gap statement has been updated to indicate that SAE J2894/2 was still in development when version 2.0 of this roadmap was published. Once it is published, the partial gap on power quality identified in version 2.0 of this roadmap will be closed.

EVSE Charging Levels/Modes

A revision to SAE J1772™ is in progress for clarification and refinement purposes.

SAE has authorized a document for three-phase AC charging for electric vehicles. This document, SAE J3068, EV Power Transfer using Three-phase Capable Coupler, covers the general physical, electrical, functional, testing, and performance requirements for conductive power transfer to an electric vehicle using a coupler capable of, but not limited to, transferring three-phase AC power. It defines a conductive power transfer method including the digital communication system. It also covers the functional and dimensional requirements for the vehicle inlet, supply equipment outlet, and mating housings and contacts. The document is targeted towards charging at commercial and industrial locations or other places where three-phase power is available and preferred.

A new project currently in development is: IEEE P2030.1.1, Standard Technical Specification of a DC Quick Charger for Use with Electric Vehicles. The IEEE Project Authorization Request states that other organizations are developing quick charging applications and this standard is not intended to overlap those activities, but to provide an additional solution to the marketplace. It notes that other standards or projects with a similar scope include IEC 62196-3, IEC 61851-23 and -24.

Partial Gap: **EVSE charging levels.** At the time of release of version 1.0 of this roadmap, the levels for DC charging within SAE J1772™ had yet to be finalized.

Recommendation: Complete work to establish DC charging levels within SAE J1772™. **Priority:** Near-term. **Potential Developer:** SAE. **Grid Related:** Yes. **Status of Progress:** Closed. **Update:** No change. This gap was deemed closed at the time of publication of version 2.0 of the roadmap.

EV Supply Equipment and Charging Systems

Partial Gap: **Off-board charging station and portable EV cord set safety within North America.** At the time of release of version 1.0 of this roadmap, the harmonization of equipment safety standards within North America based on the UL 2594 standard was still underway.

Recommendation: Finish North American harmonization effort based on UL 2594 addressing off-board charging station and portable EV cord set safety **Priority:** Near-term. **Potential Developer:** UL, CSA, ANCE (Mexico), NEMA. **Grid Related:** Yes. **Status of Progress:** Closed. **Update:** This gap was deemed closed at the time of publication of version 2.0 of the roadmap, with the publication of the North American tri-national standard based on UL 2594 in February 2013. Since that time, a Phase 2

harmonization effort has begun in CANENA to address additional technical items. There will also be a need to address NEC® 2014 technical issues in the tri-national standard.

Partial Gap: Off-board charger safety within North America. Harmonization of equipment safety standards within North America is needed.

Recommendation: There appears to be a need to harmonize the safety requirements for off-board chargers with the U.S., Canada, and Mexico. **Priority:** Mid-term. **Potential Developer:** UL, CSA, ANCE (Mexico), NEMA. **Grid Related:** Yes. **Status of Progress:** Not started. **Update:** No change.

The third edition of IEC 61851-1 is still in development and targeted for June / July 2015. The first editions of IEC 61851-21-1 and 61851-2-2 are still in development. First editions of IEC 61851-23 and IEC 61851-24 were published in 2014.

Partial Gap: Off-board charger, off-board charging station and portable EV cord set safety globally. There are some differences between the IEC 61851 series of standards and the North American standards. While not a gap per se with respect to the U.S. market, the use of infrastructure equipment and the means to mitigate risks would prove beneficial to manufacturers if harmonization was completed.

Recommendation: Work to harmonize the IEC 61851 series standards and the North American standards. **Priority:** Mid-term. **Potential Developer:** UL, IEC. **Grid Related:** Yes. **Status of Progress:** Not started. **Update:** No official harmonization effort is taking place but there are informal discussions about aligning the standards when opportunities arise.

EV Couplers: Safety and Harmonization Efforts

Partial Gap: EV coupler safety within North America. At the time of publication of version 1.0 of this roadmap, harmonization of EV coupler safety standards within North America based on the UL 2251 standard was still underway.

Recommendation: Finish efforts to harmonize standards addressing EV coupler safety within North America. **Priority:** Near-term. **Potential Developer:** UL, CSA, ANCE (Mexico), NEMA. **Grid Related:** Yes. **Status of Progress:** Closed. **Update:** This gap was deemed closed at the time of publication of version 2.0 of the roadmap, with the publication of the North American tri-national standard based on UL 2251 in February 2013. Since that time, a Phase 2 harmonization effort has begun in CANENA to address additional technical items.

Version 2 of IEC 62196-1 and version 1 of IEC 62196-3 were published on June 1, 2014. Version 2 of IEC 62196-2 is still in development. A new Chinese AC coupler is being proposed for inclusion in the document.

Partial Gap: EV coupler safety globally. There are some differences between the IEC 62196 series standards and the North American EV coupler safety standards. While not a gap per se with respect to the U.S. market, global harmonization would help to reduce costs for vehicle manufacturers.

Recommendation: Work to harmonize the IEC 62196 series standards and the North American EV coupler safety standards. **Priority:** Mid-term. **Potential Developer:** UL, IEC. **Grid Related:** Yes. **Status of Progress:** Not started. **Update:** No official harmonization effort is taking place but there are informal discussions about aligning the standards when opportunities arise.

There is a need to address the issue of field failures with connectors overheating. There are some compatibility issues between connectors and inlets from different suppliers, made of different contact materials, contact types and ratings that are being mixed in the field possibly creating some of the issues. The reasons are unclear but some chargers have been taken out of service. The issue is being looked at by the IEC 62196 group and by CANENA. SAE also has a working group looking at it and on additional test procedures to add to UL 2251. ISO 17409.2 is also still in development. Aspects of this issue are also being addressed in version 6 of SAE J1772™ as an informative annex. Idaho NL is also working on this issue. This is an issue the root cause of which has yet to be ascertained. If it turns out to have a standards related component to it, it will be addressed in future iterations of relevant documents.

EV Couplers: Interoperability with EVSE and Harmonization Efforts

An ongoing issue being discussed in ISO and IEC is whether a type 2 coupler in its present configuration is allowed for AC and DC charging where both forms of power can occur on the same contact pins. This is allowed in the SAE specification. As noted above, IEC 62196 parts 1 and 3 were published on June 1, 2014. They include configurations that have separate AC and DC pins. They do not include configurations that use common pins for AC and DC charging. So this may be a harmonization issue between SAE and IEC. The vehicle control aspects of AC and DC charging in ISO 17409.2 also come into play.

Partial Gap: EV coupler interoperability with EVSE globally. Different coupler configurations are used in different parts of the world. Global harmonization would help to reduce costs for manufacturers. At the time of release of version 1.0 of this roadmap, the revision of SAE J1772™ was still in progress; it has now been published.

Recommendation: Incorporate the new SAE J1772™ combination coupler into IEC 62196-3. Build out the charging infrastructure to accommodate variations in EV coupler configurations for particular markets as necessary, in particular with respect to DC charging. **Priority:** Near-term. **Potential Developer:** SAE, IEC, ISO, CHAdeMO, vehicle and charging station manufacturers. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The combo coupler configuration is included in IEC 62916 part 3. The gap statement and

recommendation have not been modified. However, the text has been updated to note the differences between the SAE and IEC standards in terms of allowing AC and DC charging to occur on the same contact pins. ISO has been added as a developer.

Conformance Programs

The first edition of SAE J2953/1, Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE), providing requirements, was published in 2013, and the first edition of SAE 2953/2, Test Procedures for the Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE), was published in 2014. A revision to Part 1 is in progress that includes updates from version six of SAE J1772™ and deals with DC charging interoperability for communications. Part 2 is also undergoing revision and should be published soon. Joint testing is to be performed at Argonne National Laboratory in November 2014.

Gap: Conformance programs for EV coupler interoperability within the U.S. market. A program(s) is needed for the U.S. market to verify compatibility between the EV coupler, the infrastructure and the vehicle.

Recommendation: Complete work on SAE J2953. Establish a program(s) to verify interoperability between infrastructure equipment, including the vehicle connector, and all vehicles that follow the SAE J1772™ protocol. **Priority:** Near-term. **Potential Developer:** SAE, UL. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The gap statement is largely addressed with the publication of the two parts of SAE J2953. No information has been provided on the status of the UL verification program.

4.2.1.4 Electromagnetic Compatibility (EMC)

See also section 4.2.1.1 in relation to wireless charging.

IEC 61851, parts 1 and 2, are still in development. They will replace IEC 61821-21 when completed.

Gap: Electromagnetic compatibility (EMC). Standards to address EMC issues related to electric vehicle charging are still in development.

Recommendation: Complete work on IEC 61851-21, Parts 1 and 2, and SAE J2954 to address EMC issues related to electric vehicle charging. **Priority:** Near-term. **Potential Developer:** IEC/TC 69, SAE. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** Work on IEC 61851-21, parts 1 and 2, and SAE J2954 continues.

4.2.1.5 Vehicle as Supply

Vehicle to Grid (V2G) is a concept in which an EVSE and EV act together to become a distributed energy resource (DER). The emerging EVSE-EV DER is a new player in the larger DER world of solar PV systems, small wind turbines, stationary storage systems, gas microturbines, and other distributed generation. A device called an inverter must be installed in either the EVSE or the EV to convert DC energy from the EV

battery into AC current that can be synchronized with the grid. In actual practice the charger and inverter functions would be integrated into a single bidirectional converter, but the device is commonly referred to as an inverter. An EVSE-EV DER can discharge energy from the EV battery into the grid in two ways. The inverter can be located in the EVSE, with only DC power flowing from the EV battery to the EVSE, which from a utility perspective is like a stationary storage DER with an interchangeable battery. Alternatively, the inverter could be located on-board the vehicle. However, this concept of a roaming inverter is unprecedented from a utility perspective.

Working groups of EPRI and IEC continue to define a set of standard functions that could be implemented by an inverter-based DER. EPRI publishes these from time to time in a report titled "Common Functions for Smart Inverters." IEC plans to include these functions in the next release of its DER object model in IEC 61850-7-420, but has been using a series of technical reports to document them in the interim. IEC/TR 61850-90-7 was published in February 2013 for this purpose. SAE J2836/3TM, published in January 2013, defined several inverter functions which should be considered for use in V2G applications based on available draft EPRI and IEC reports. However, SAE extended the EPRI/IEC basic charge/discharge function to reflect the need for an EV to achieve a target state of charge by a defined departure time. SAE worked with EPRI to include this function in version 3 of its report which was published in February 2014. It is expected that IEC will include the changes from the EPRI report in the 61850 object model.

For V2G applications some entity must communicate with the inverter system to interact with one or more of the functions that are implemented by the inverter. When the inverter is located on-board the EV, the DER controller needs to engage with the EV inverter system and not with the EVSE, except where the EVSE may need to serve as a protocol translator between the DER controller protocol and the EV protocol. But the DER controller and EV inverter system need to mutually engage as defined by the common functions.

The Smart Energy Profile 2.0 (SEP 2.0) Application Protocol, which has now been adopted as IEEE 2030.5, includes a DER function set which is based on IEC/TR 61850-90-7, but also includes the additional information required by SAE J2836/3TM. SAE J2847/3, which was published in December 2013, provides guidance for using the flow reservation and DER function set of SEP 2.0 for an EV with an on-board inverter system. However, an EV could use a different protocol to engage with the DER controller.

For the case where the inverter system is located in the EVSE, the DER controller should directly engage with the EVSE. The EV should not come between the EVSE and the DER controller in the execution of the inverter functions. For an EVSE that uses SEP 2.0, SAE J2847/3 could be used for guidance for communication with the DER controller. The EVSE must communicate with the EV to ensure that the EVSE inverter does not push or pull too much current from the EV battery when executing the smart inverter functions. The DC fast charging communication needs to be modified to include the required DER mode. This will be documented in a future version of SAE J2847/2.

The interconnection to the electric power system of any DER device must be approved by the local utility before any energy can be supplied. For the case where the inverter is located in the EVSE, the

EVSE would be tested and listed to UL 1741 and traditional review and approval processes could be followed. The case for the on-board inverter is more challenging for two reasons.

One reason is that the on-board inverter cannot be listed to UL 1741. This standard has many requirements that are not appropriate for equipment integrated into a vehicle. Also the inverter function in an EV will be a distributed system and not a specific device within the EV. UL 1741 is primarily focused around a self-contained “box.” SAE is developing the SAE J3072 standard to establish requirements for a utility-interactive inverter system which is integrated into an EV. The requirements will be limited to those which are necessary to secure approval for interconnection with the electric power system. It is expected that the vehicle manufacturer (VM) would certify conformance to SAE J3072.

The other reason is that the inverter is not fixed to the premises; only the EVSE is fixed. All of the existing approval processes are based on a fixed inverter. If the application to the utility is made only on the basis of the EVSE model which is used at the location, the utility would not have any direct approval over the actual inverter. This will require a change in the approach to mobile EV inverters with 3300 utilities in the United States. This issue is being discussed with regulatory authorities in several states.

UL 9741, Outline of Investigation for Bidirectional Electric Vehicle (EV) Charging System Equipment, was published in March 2014. This document essentially combines the inverter requirements of UL 1741 with the EVSE charging system requirements of UL 2594 (for AC transfer) and UL 2202 (for DC transfer). For the case where the converter is located in the EVSE, an EVSE tested and listed to UL 9741 would also be listed to UL 1741 which would still be used as the basis for the interconnection application with the utility. An EV with an on-board bidirectional converter would not be able to discharge when connected to an EVSE which is only listed to UL 2594 because it would not be interoperable with an EV which conforms to SAE J3072. UL 9741 could be modified to become the EVSE standard for use with EVs with onboard inverters that conform to SAE J3072. Efforts are underway between UL and SAE to see how UL 9741 can be harmonized with the SAE J3072 activities.

There is growing interest today in the use of smart inverters to more effectively integrate distributed energy resources (DER) into the grid. This is primarily being driven by the increased penetration of solar PV systems which could destabilize the grid at some level of penetration. But by including certain smart inverter functions in the PV systems, they can help to stabilize the grid. There is also interest in the use of electricity storage systems to help match energy supply and demand of renewable sources as well as provide voltage and frequency stability. A vehicle with a four quadrant converter is a storage DER and could be capable of performing the same grid support functions as a solar PV inverter or a stationary energy storage system. All of these functions can be considered as V2G applications. IEC 61850-90-7, UL 9741, SAE J2836/3TM, SAE J2847/3, and J3072 standards all support these types of Vehicle Grid Integration.

The California Public Utility Commission (CPUC) has several rulemaking proceedings that relate to V2G. The most relevant to V2G is the Alternative-Fueled Vehicles proceedings. These are specifically addressing Vehicle Grid Integration, including V2G. Also relevant is the Rule 21 proceeding which is now

addressing which smart inverter functions should be required for inverter-based DER and the means for a utility to communicate with each DER. The primary focus is on solar PV because it is creating the stability problem. The Energy Storage proceeding also considers V2G as one form of providing storage. Before unintended consequences result, CPUC must enumerate the differences that exist between mobile and stationary inverters. Such work may best be included within the scope of the Rule 21 smart inverter working group so as to be certain the unique characteristics of mobile inverters are accounted for and not prevented from interconnecting and providing benefits to the grid behind and beyond the meter. Coordination with the Storage and Alternative Fueled Vehicle proceeding is essential.

As a separate matter, New York State has launched the Reforming the Energy Vision (REV) proceeding to deal with DER, which may restructure the role of the state utilities in integration of DER, including V2G.

Gap: Vehicle as supply / reverse power flow. The version 2.0 roadmap gap stated that differences exist between the DER model defined by SAE J2836/3™, IEC/TR 61850-90-7, IEC/TR 61850-90-8, and SEP 2.0.

Recommendation: The version 2.0 roadmap recommendation was to harmonize the information model for an EV as a DER between SAE J2836/3™, IEC/TR 61850-90-8, and SEP 2.0. **Priority:** Near-term.

Potential Developer: SAE, IEC/TC 57, IEEE. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The roadmap version 2.0 text has been substantially revised. SAE J2836/3™ functionality aligns with SEP 2.0, so that aspect of the gap is closed. SEP 2.0 has been published by the IEEE which has been added as a developer (ZigBee Alliance and the HomePlug Powerline Alliance had transferred SEP 2.0 to IEEE.) SAE worked with EPRI to align Version 3 of their Common Functions for Smart Inverters report with SAE J2836/3™. IEC is using the EPRI V3 report to directly update the actual DER model contained in IEC 61850-7-420 rather than flow it using an interim technical report, such as IEC/TR 61850-90-8 or 90-9. This part of the gap will be closed once IEC 61850-7-420 is published.

Gap: Certification Standards for Mobile inverters. UL 1741 is the safety standard for inverters which connect to the grid. It is not appropriate for distributed inverter systems within an EV. A new standard is needed for on-board inverter systems. UL 2594, Electric Vehicle Supply Equipment, is the safety standard for an EVSE that connects to an EV with an on-board charger but it does not cover the unique requirements for interconnection with an EV with an on-board inverter.

Recommendation: Create SAE J3072 which can be used to ensure that an EV with an on-board inverter system can be safely interconnected to the electric power system. Modify UL 9741 to serve as the standard for an EVSE which is interoperable with an EV inverter system which conforms to SAE J3072.

Priority: Near-term. **Potential Developer:** SAE and UL. **Grid Related:** Yes. **Status of Progress:** New Gap / Green.

Gap: Mobile inverters: interconnection agreements. There are no simple utility procedures to approve an EV with an on-board inverter to interconnect to the grid.

Recommendation: Coordinate an approach with utilities and federal and state government agencies on how an EV with an on-board inverter can be approved to discharge at a specific EVSE location. **Priority:** Near-term. **Potential Developer:** key utilities with V2G interest, Federal Energy Regulatory Commission, DOE, State PUCs, and others. **Grid Related:** Yes. **Status of Progress:** New Gap / Red.

4.2.1.6 Use of Alternative Power Sources

Gap: Use of alternative power sources. The National Electrical Code® does not specifically address the integration of the EV and EVSE with a facility high voltage DC power distribution system for either charging or reverse power flow.

Recommendation: Develop NEC® requirements for high voltage DC power distribution systems and the integration of distributed energy resources and DC loads with the system. **Priority:** Near-term. **Potential Developer:** NFPA. **Grid Related:** Yes. **Status of Progress:** Green **Update:** This remains an open issue.

4.2.2 Infrastructure Communications

4.2.2.1 Communications Architecture for EV Charging

SAE Task Force Activity: PEV/EVSE Communications (Note: documents are in development except where noted otherwise)

Use Case Document Status – Technical Information Report (TIR)

- J2836/3™ - PEV as a Distributed Energy Resource (DER) Use Cases. V2 has been reopened to address on-board inverter requirements and testing.
- J2836/4™ - Diagnostics Use Cases. V1 has started for failures on the control pilot and prox, but is waiting for J2953/1 & /2 (Interoperability) for more data.
- J2836/5™ - Customer to PEV Use Cases. V1 started the ballot cycle and is expected to be published 1Q, 2015 to include Use Cases (U8 & U9) (see section 4.2.2.5).
- J2836/6™ - Wireless Charging Use Cases. V1 was published 2013-5-3.

Signal/Message Document Status – Recommended Practice (RP)

- J2847/1 - Utility signals/messages. V4 was published 2013-11-5.
- J2847/2 - DC Charging. V3 is in being formatted for publication and needs a final ballot by the SAE Motor Vehicle Council. It aligns with implementation and harmonization with DIN SPEC 70121 Candidate 6a. Minor changes are required to harmonize with ISO 15118-2 & -3 message names and schema updates and will be addressed next year in V4. This document is the basis for Wireless Charging and V4 is expected to track progress of J2847/6 and ISO 15118-6, 7 & 8 as they move through their initial completion cycle.

- J2847/3 - PEV as a Distributed Energy Resource (DER). V1 was published 2013-12-10.
- J2847/4 - Diagnostics. Work has started but is waiting for J2836/4™ & J2953/1 & /2 (Interoperability).
- J2847/5 - Customer to PEV. Work is waiting for J2836/5™ Use cases.
- J2847/6 - Wireless Charging messages. V1 is in the ballot cycle, aligning with ISO 15118-6, 7 & 8. V2 will be reopened as needed to capture significant changes during the ISO completion cycle.

Requirements and Protocol Documents - TIR

- J2931/1 - Protocol Requirements. V3 is being formatted for publication which is expected before the end of 2014. It includes DC Charging updates and high level security items. Additions are required from the clarifications to DIN SPEC 70121 for DC Charging, and the task force is also addressing comments from the Smart Grid Interoperability Panel (SGIP) Smart Grid Cybersecurity Committee (SGCC) Standards Review to add this document into the Catalogue of Standards (Cos). It will be re-opened as V4 for security.
- J2931/4 - BroadBand (BB) PowerLine Carrier (PLC) - wired communication protocol. V3 was reopened to add DIN SPEC clarifications. It was published October 20, 2014 and addresses DC Charging items.
- J2931/5 - Telematics - wireless communication protocol. This is waiting for J2847/5.
- J2931/6 – Vehicle to Vehicle Communication (IEEE 802.11p) wireless charging protocol. This is started but waiting for J2847/6.
- J2931/7 - Security. Work has been restarted.

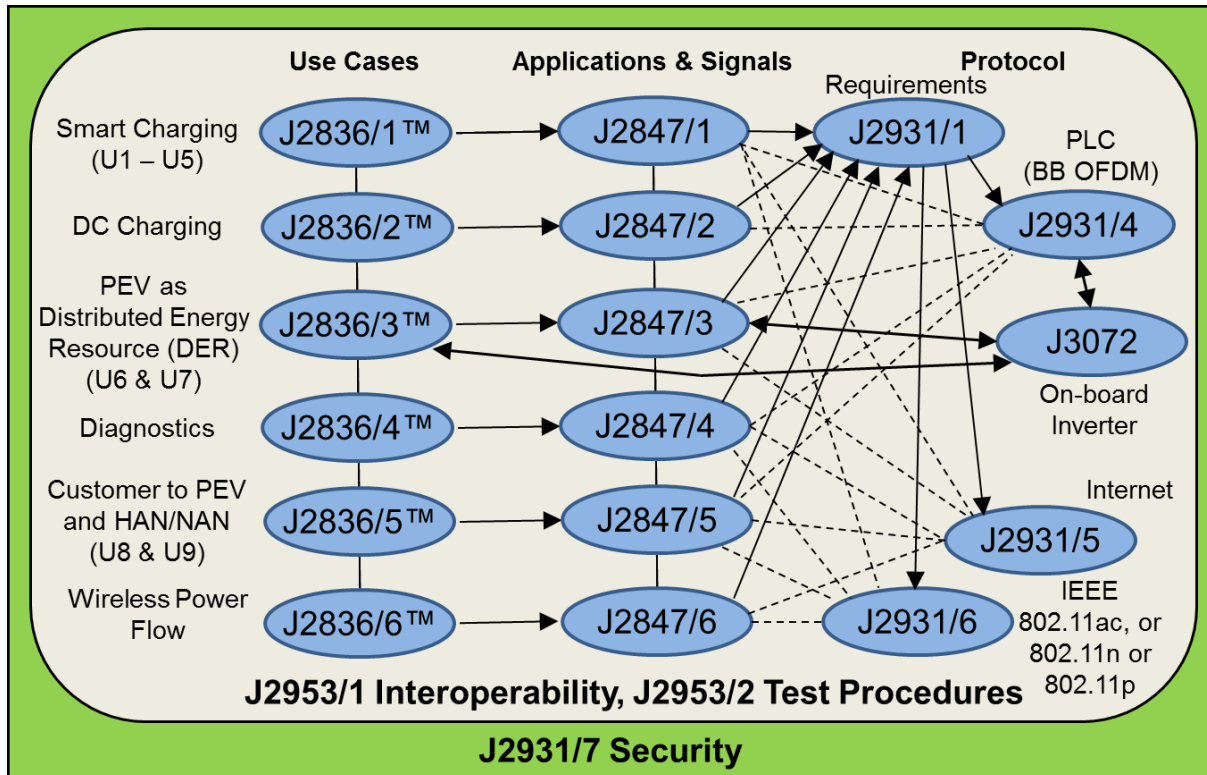
Interoperability Documents - RP

- J2953/1 - Requirements. V1 was published 2013-10-07. V1 addressed the analogue communications (J1772™ control pilot and prox). V2 is addressing digital communication for DC charging.
- J2953/2 - Test plan. V1 was published 2014-01-22. V2 is being updated to correlate with J2953/1.

Requirements and Testing Documents

- J3072 - Interconnection Requirements for Onboard, Utility-Interactive, Inverter Systems. This is a new standard (not an RP) to address on-board inverters as a DER source.

SAE Document Interaction (Updated Chart)



**Figure 1: The Interaction of SAE EV Communication Standards Documents
(Used with Permission of SAE International)**

Other Notable Activity

ISO 15118, Parts 1 and 2 have been published; Parts 3 through 8 are in development (note: these documents have only the ISO acronym in their designation).

SEP 2.0 was published in April 2013, adopted as a standard by IEEE as P2030.5 in November 2013, and accepted into the SGIP Catalogue of Standards in March 2014. IEEE will handle future revisions of the standard, while the Consortium for Smart Energy Profile (CSEP), which consists of the Wi-Fi Alliance, Bluetooth Alliance, Zigbee Alliance, and HomePlug Alliance, is in charge of testing and certification.

4.2.2.2 Communications Requirements for Various EV Charging Scenarios

Locating and Reserving Public Charging Stations (EVSE), and Roaming

Multiple Standards Development Organizations (SDOs) are actively working on standardization of locating and reserving charging stations, and on the standardization of inter-provider protocols required for various aspects of EV roaming. In addition, SDOs are working on standardization of communications between charging stations and the back office software systems that manage them.

The U.S.-based SDO **NEMA** created a working group (WG) called **5EVSE Roaming WG**, to work on standards for:

- finding, identifying and reserving charging stations and EV users,
- authenticating and authorizing charging station users,
- accounting and fault reporting of EV charging sessions.

This WG assumes that EV charging stations are deployed as networks of stations managed by different administrative entities, and that EV drivers subscribe to charging plans instituted by charging service providers. It aims to provide the above functionality across multiple networks and service providers, by standardizing the data that can be exchanged between actors, and standardizing the communication interfaces used to exchange the data. For example, charging stations and their capabilities are modeled in a standard way, such that static and dynamic (time-variant) data for any station conforming to the standard may be communicated or queried.

The NEMA 5EVSE Roaming WG is working on the following components of a standard in a multi-part series:

- EVSE 1.1, EV Charging Network Interoperability Standards Framework
- EVSE 1.2, A Contactless RFID Credential for Authentication (U_R Interface)
- EVSE 1.3, QR Code and NFC Tags for EV Charging Station Identification (U_T Interface)
- EVSE 1.4, Data Model and Protocols for Distributing Station Directories (I_D Interface)
- EVSE 1.5, Authentication and Authorization Across EV Charging Networks (I_A Interface)
- EVSE 1.6, Charging Session Status and Accounting Data Exchange (I_C Interface)

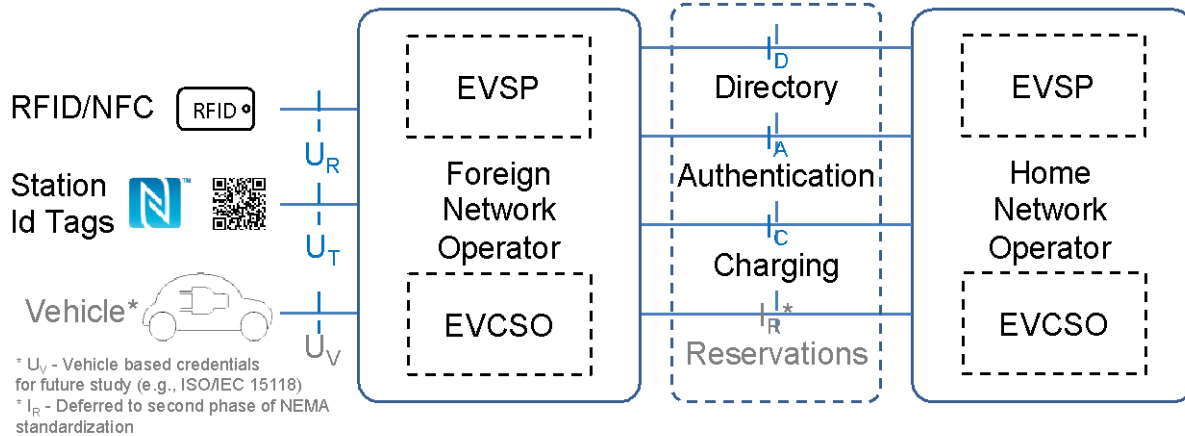
EVSE 1.2 has been approved already. NEMA is finalizing EVSE 1.4 at this time.



Interface Standardization Reference Points

User-Side Interface

Inter-Operator Interface



- Station Directory (I_D) Provides an Integrated View of Stations on Participating Networks Along with Real-Time Status
- Common Station Identification (U_T), Subscriber RFID Credentials (U_R), and Authentication Protocols (I_A) Enable Service Activation Across Any Network
- Roaming Service with Charging Status and Billing Data Across Networks (I_C)
- Initial Focus on Basic Mode Charging Interoperability (Defer ISO/IEC-15118 High Level Communication U_V)

**Figure 2: Interface Standardization Reference Points
(Used with Permission of NEMA)**

Please refer to the diagram above to see where the NEMA standards fit in, architecturally. Note that standardization of a means of reserving charging stations is not currently a priority for the NEMA 5EVSE Roaming WG.

NEMA intends to propose these specifications for international (ISO/IEC) standardization via ANSI.

eMI³ (see <http://emi3group.com>), an international interest group under the umbrella of ERTICO, is based in Europe, and is working on standardizing a superset of the functionality being worked on in NEMA. In addition to working on finding and reserving charging stations in inter-network, inter-operator situations, eMI³ also intends to work on intra-operator communications between charging stations and the operator "back end" systems. While the eMI³ work is greater in scope than the NEMA 5EVSE work, the NEMA work is currently in a more advanced state. eMI³ and NEMA have established a liaison, whereby ideas have been exchanged in both directions, and harmonization is being sought. Due to the differences in the deployment and management of EV charging networks in Europe and the U.S., the harmonization may not be perfect. However, the intent is to minimize the effort required by providers

and vendors, by harmonizing as much as possible. Both organizations are optimistic about the outcome. The first eMI³ publication is anticipated to include:

- Part 1: Use Cases
- Part 2: Unique Identifiers (eMA ID, Token ID, EVSE ID, EVSE Pool ID) and Station Directory Business Objects
- Parts 3, 4: For future use
- Part 5: Interface for EVSE to EVSE Operator back end communication
- Part 6: Interface for Smart Charging Provider to Energy Market communication
- Part 7: Interface for Smart Charging Provider to EV (via OEM back end)

The **Open Charge Alliance (OCA)** (see <http://www.openchargealliance.org>) is, in its own words, "a global consortium of public and private electric vehicle (EV) infrastructure leaders that have come together to promote open standards like the adoption of the Open Charge Point Protocol (OCPP)." Currently, OCA's focus is on OCPP, an intra-network communications protocol (i.e., a protocol between a charging station and the operator "back end" systems). There is thus an overlap between this work and similar work being contemplated in eMI³. The eMI³ work may use a different protocol than OCPP, or it may create a "fork" of OCPP, and use that as a basis for its own OCPP-compatible protocol.

The **ETSI** Intelligent Transport Systems (ITS) Infrastructure to Vehicle Communications Section is working on a "Communication system for the planning and reservation of EV energy supply using wireless networks," under the TS 101 556-3 document. eMI³ has reviewed this document, and is writing a response to ETSI. The response is anticipated to state that the ETSI work addresses a subset of the reservation use cases identified by eMI³. The eMI³ standards may include the scope of work addressed by TS 101 556-3.

The table below shows equivalences between work in NEMA, eMI³, OCA and ETSI:

NEMA 5EVSE	eMI ³	OCA	ETSI
U _R	Part 2 (Business Objects)		
U _T	Part 2 (Business Objects)		
I _D	Part 2 (Station Directory)		
I _A	Part 5	OCPD	
I _C	Part 5	OCPD	
	Part 6		
	Part 7		
I _R (Future reservation protocol?)	Part N		TS 101 556-3

Gap: Locating and reserving a public charging station. There is a need for a messaging standard to permit EV drivers to locate a public charging spot and reserve its use in advance.

Recommendation: Develop a messaging standard to permit EV drivers to universally locate and reserve a public charging spot. **Priority:** Mid-term. **Potential Developer:** SAE, ISO/IEC JWG, NEMA, eMI³, OCA. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The text has been updated to note recent developments. eMI³ and OCA have been added as potential developers.

Gap: Charging of roaming EVs between EVSPs. There is a need to permit roaming EVs to charge at spots affiliated with a different EVSP.

Recommendation: Develop back end requirements as well as an interface standard that supports charging of roaming EVs between EVSPs. **Priority:** Near-term. **Potential Developer:** NEMA, IEC, eMI³. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** The text has been updated to note recent developments. eMI³ has been added as a potential developer.

Access Control

Gap: Access control at charging stations. There is a need to develop data definition and messaging standards for communicating access control at charging stations.

Recommendation: Develop data definition and messaging standards for communicating access control at charging stations. **Priority:** Mid-term. **Potential Developer:** NEMA. **Grid Related:** Yes. **Status of Progress:** Yellow. **Update:** As noted in roadmap version 2.0, the NEMA 5EVSE Network Roaming WG looked at this roadmap version 1.0 gap, decided that offline access control lists were a low priority, and deferred action on offline access control to a later phase of work. Priority changed to mid-term.

4.2.2.3 Communication and Measurement of EV Energy Consumption

Utility Interface Standard

Gap: Communication of standardized EV sub-metering data. Standards are needed for communication of EV sub-metering data between third parties and service providers.

Recommendation: Complete Green Button Sub-metering Profile of ESPI for communication of standardized EV sub-metering data, for example, between a third party and a billing agent (e.g., utility).

Priority: Near-term. **Potential Developer:** OpenADE/NAESB. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** No change. ESPI sub-metering profile of Green Button Connect My Data still in progress.

Requirements and Guidelines on Standards for Third Party Sub-meters

NEMA

NEMA 5EVSE Metering WG is developing a guide for EVSE embedded metering and communication. The purpose of this document is to provide guidance for EVSE applications that include an embedded metering function that incorporates a communication protocol for monitoring or monitoring and control. The ultimate intent however is to end up with a certification standard recognized by authorities having jurisdiction (AHJs). Stakeholders expected to benefit from this document include EVSE manufacturers, utilities, automakers, EV drivers, EVSE owners, and regulators.

The guide will recommend key requirements and testing methods for embedded metering functions including tamper resistance, accuracy, communication, security, and reliability. It makes distinction of two major use cases: residential and commercial implementations. The applicable EVSEs in the document include both AC and DC Levels 1 and 2.

NIST's U.S. National Work Group on Measuring Systems for Electric Vehicle Fueling and Submetering

Since August 2012, the NIST U.S. National Work Group on Measuring Systems for Electric Vehicle Fueling and Submetering (USNWG EVF&S) has periodically met to develop proposed requirements for commercial electricity-measuring devices (including those used in sub-metering electricity at residential and business locations and those used to measure and sell electricity dispensed as a vehicle fuel) and to ensure that the prescribed methodologies and standards facilitate measurements that are traceable to the International System of Units (SI). This work on legal metrology standards is not intended to address utility metering in the home or business where the metered electricity is consumed by the end purchaser and that falls under the authority of entities such as the local utility commission.

The USNWG EVF&S's technical output may result in the revision of current standards or the development of new standards for requirements and testing procedures for commercial devices and systems used to assess fees and charges to consumers for electric vehicle fuel.

In July 2013 a Uniform Regulation for the Method of Sale of Electricity Sold as a Vehicle Fuel was adopted by the National Conference on Weights and Measures (NCWM) and is now published in NIST Handbook (HB) 130 (2014) *Uniform Laws and Regulations in the Areas of Legal Metrology and Engine Fuel Quality*. The regulation is available on the NIST Office of Weights and Measures website.⁷ This regulation specifies: (1) the unit of measurement (kWh); (2) requirements for labeling the unit price, other associated fees, fuel rating, and NEC®/NFPA information on equipment; and (3) pricing and service information to be included in advertisements when electrical energy is sold as a vehicle fuel.

The USNWG EVF&S submitted and received support from the state and local weights and measures community for a draft device code and modified timing devices code for national adoption by July 2015. The codes would address the device's design, accuracy, installation and use requirements, and test procedures that would be published in NIST Handbook 44 *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*. Since October 2013 the USNWG has worked to refine a draft device code that includes 83 new terms. A USNWG EVF&S Subcommittee was also established to work on draft field test standard requirements and test procedures.

The technical output of the USNWG EVF&S may also be published in documents such as the NIST Handbook 105 Series for field standards; NIST Examination Procedure Outlines for use in field evaluation; and in NIST Materials for training of officials and industry on the test and inspection of equipment to NIST HB standards. The USNWG will also work to harmonize device requirements, wherever possible, with related international documents such as OIML Recommendation 46 *Active electrical energy meters*.

SGIP PAP-22 Working Group

The SGIP initiated Priority Action Plan (PAP) 22 to coordinate the development of EV Refueling Sub-meter Requirements. The PAP-22 Working Group consists of representatives from the NEMA 5EVSE Metering WG, ANSI Accredited Standards Committee C12, USNWG EVF&S, national labs, automakers, utilities, and EVSE manufacturers. The primary elements to be addressed are access, accuracy, tamper resistance, performance, reliability, data requirements, security, testing and certification. The focus of the PAP22 activity is the development and completion of the NEMA Embedded Metering and Communications Guide. The content of the NEMA guide is being reviewed and coordinated through the PAP22 work group with the USNWG EVF&S. The key task is the integration and harmonization of the specifications and certification requirements for EV sub-metering from the NEMA Guide with NIST

⁷ <http://www.nist.gov/pml/wmd/usnwg-evfs.cfm>

Handbook 44 which ensures accuracy and reliability in the measurement of electricity as a transportation fuel for retail sale to consumers. Key performance standards related to embedded EVSE sub-metering include: UL 2231, UL 2594, and SAE J1772™.

Gap: **Standardization of EV sub-meters.** Standards for EV sub-meters, including embedded sub-meters, need to be completed to address performance, security/privacy, access, and data aspects.

Recommendation: Develop standards or guidelines related to the functionality and measurement characteristics of the new types of sub-meters that are coming out for EVs, including embedded sub-meters in the EVSE or EV. Such standards should address different form factors, capabilities, installation, and certification. **Priority:** Near-term. **Potential Developer:** NEMA, USNWG EVF&S, SGIP PAP-22 WG.

Grid Related: Yes. **Status of Progress:** Green. **Update:** Work is proceeding as described in the text. SGIP PAP-22 WG was added as a potential developer.

Gap: **Coordination of EV sub-metering activities.** Various existing activities (NEMA, USNWG EVF&S, SGIP PAP-22 WG) need to be coordinated as much as possible.

Recommendation: Organizations developing standards, guidelines or use cases related to EV sub-metering should coordinate their activities in order to avoid duplication of effort, assure alignment, and maximize efficiency. **Priority:** Near-term. **Potential Developer:** NEMA, USNWG EVF&S, SGIP PAP-22 WG.

Grid Related: Yes. **Status of Progress:** Green. **Update:** Work is being coordinated among NEMA, USNWG EVF&S, and SGIP PAP-22 WG. Note: The reference to SGIP V2G DEWG has been changed to SGIP PAP-22 WG.

4.2.2.4 Cyber Security and Data Privacy

Work to revise SAE J2931/7 on security for PEV communications has been re-started. ISO 15118/1 was published in April 2013.

Draft NISTIR 7628 Revision 1 was released for public comment from October 25 to December 24, 2013. Approximately 242 comments were received on the 3 volumes. The Smart Grid Interoperability Panel (SGIP) Cybersecurity Committee subgroups and NIST staff are resolving the comments. Among other proposed changes, chapter 5, on privacy and the smart grid, has been updated to reflect changes in the regulatory and legislative areas regarding the smart grid as well as emerging PEV technologies and associated privacy concerns.

Gap: **Cyber security and data privacy.** There is a need for guidelines and standards to address cyber security and data privacy concerns associated with PEVs and smart grid communications.

Recommendation: Complete work to develop SAE J2931/7, and to revise ISO 15118-1 and NISTIR 7628, volume 2. **Priority:** Near-term. **Potential Developer:** SAE, ISO/IEC JWG, NIST. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** As noted in the text.

4.2.2.5 Customer to PEV Communications

SAE J2836/5™ is to provide the use cases for development of the requirements for SAE J2847/5, Customer Communications for Plug In Electric Vehicles. The purpose of the standard is to identify the customer required interactive information for execution of various charging infrastructure features. There are two primary use case categories being addressed: U8 Customer Convenience Functions and U9 Network Synchronization. Customer Convenience Functions use cases are remote start/stop charging, cabin conditioning, setting customer preferences, electricity usage information, charge status notifications/alerts, and EVSE site location/reservation. Use cases for Network Synchronization address conflicts between the PEV driver preferences and the load management control point criteria for demand response, demand charge control, load balancing, etc. Load management control points can be the facility EMS, the utility, 3rd party EV services provider, and the ISO/RTO. The use case is to address the information required by the customer for such conflicts and a process for conflict resolution. The standard will also relate an understanding of the potential communications interface points to the customer for interactive information.

Gap: Customer to PEV communications. There is a need to develop use cases related to customer vehicle information including non-utility aggregation control in order to assess the existing functionalities, and to determine any missing requirements within the context of existing standards, Energy Service Provider business requirements, and telematics networks to support smart grid load management.

Recommendation: Complete work to develop SAE J2836/5™. **Priority:** Near-term. **Potential Developer:** SAE. **Grid Related:** Yes. **Status of Progress:** Green. **Update:** As noted in the text. This section has been re-named Customer to PEV communications. The gap statement has been slightly modified.

4.2.3 Infrastructure Installation

4.2.3.1 Site Assessment / Power Capacity Assessment

The 2014 NEC® Section 625.41 continues to address the ratings of electric vehicle supply equipment and that the load profile is that of a continuous duty load for the purposes of Article 625. A revision to this section added the recognition of an automatic load management system and indicated that where an automatic load management system is used, the maximum load on a feeder or service shall be the maximum load permitted by the automatic load management system. The significance of this change is that an alternative exists to use automatic load management systems to keep a service or feeder from being overloaded, rather than have the installation of EVSE force a service upgrade. The concept is similar to that of recognizing non-coincidental loads connected to the same service or feeder. Another new provision was added in 2014 NEC® Article 220, specifically Table 220.3. There is now a reference from this table to address electric vehicle supply equipment service and feeder calculations and provide the correlation to NEC® Section 625.41.

Harmonization Efforts

Regarding a harmonization assessment between NEC® Article 625, the Canadian Electrical Code and IEC 60364, the next edition of the Canadian Electrical Code, Part I, will be published in January 2015. The IEC TC 64 met last in the Spring of 2014. These documents should be reviewed and the assessment table updated as needed.

4.2.3.2 EV Charging – Signage and Parking

No new information has been provided with respect to this issue.

4.2.3.3 Charging Station Permitting

There is some feeling that, with education of the installation and inspection community, the situation at least with respect to residential charging station permitting has improved.

Challenges are raised in the NCWM for the metrological and indication performance for commercial EVSEs (public). The NIST HB 44 regulation, currently in the final stages before being submitted to the NCWM for approval next year, outlines the basic performance requirements for certification. A couple of other documents will complement it once it's approved by providing type and field test procedures. After installation, once certification is obtained, weights and measures inspectors will perform a metrological performance field test and an inspection on signage and such before certifying that the station is approved for use.

4.2.3.4 Environmental and Use Conditions

No new information has been provided with respect to this issue.

4.2.3.5 Ventilation – Multiple Charging Vehicles

No new information has been provided with respect to this issue.

4.2.3.6 Guarding of EVSE

Partial Gap: Guarding of EVSE. There is a lack of standards that address charging station design with respect to physical and security protection of the equipment.

Recommendation: Guidelines or standards relating to guarding of EVSE should be developed. **Priority:** Mid-term. **Potential Developer:** NFPA. **Grid Related:** No. **Status of Progress:** Not started. **Update:** The roadmap version 2.0 notes that NFPA 730, Guide to Premises Security, Annex E discusses the placement / design of bollards. In addition, section 110 of the (NEC®) addresses protection of electrical equipment generally. Where there appears to be a partial gap is a lack of guidance on protection of EVSE specifically. This could be developed in the 2017 version of the (NEC®). Public input on the NEC® closes 7 November 2014. The NEC® panel will meet in January 2015.

4.2.3.7 Accessibility for Persons with Disabilities to EVSE

The California Division of State Architects is beginning the development of accessibility requirements for EV charging.

Gap: **Accessibility for persons with disabilities to EVSE.** There is a lack of standards that address charging station design with respect to accessibility for persons with disabilities to EVSE.

Recommendation: Guidelines or standards relating to accessibility for persons with disabilities to EVSE should be developed. **Priority:** Mid-term. **Potential Developer:** ICC (ICC A117.1 and IBC®, IgCC™ or IZC®).

Grid Related: No. **Status of Progress:** Green. **Update:** In June 2013, proposals were made to the ICC A117.1 committee for technical criteria on how to make an EV charging station accessible. They were approved by the committee and received no public comment, so they will be in the next edition of the standard. Proposed scoping provisions (i.e., what, where and how many) for the International Building Code may be submitted to ICC by Jan. 5, 2015.

4.2.3.8 Cable Management

A new definition of the term Cable Management System (Electric Vehicle Supply Equipment) was added to NEC® Section 625.2 in Article 625 as follows:

Cable Management System (Electric Vehicle Supply Equipment). An apparatus designed to control and organize unused lengths of output cable to the electric vehicle.

The term cable management system, which is used in Section 625.17(C), generally limits the usable cable length to 7.5 m (25 feet). If a cable management system is part of listed electric vehicle supply equipment, longer output lengths are permitted and are governed under the listing of the EVSE. A related revision in NEC® Section 625.50 removes the upper height limitation of 4 feet for the means of coupling in recognition of using cable management systems installed on ceilings or elevated above floors. The other revisions in this rule address the lower height limitations for storing the means of coupling. For indoor locations it shall be stored at heights not less than 18 inches and for outdoor locations at heights not less than 24 inches.

Two new definitions have been added to NEC® 625.2 that clarify what constitutes an output cable to the electric vehicle and how it is differentiated from a power supply cord for the electric vehicle supply equipment. Below are the two definitions:

Output Cable to the Electric Vehicle. An assembly consisting of a length of flexible EV cable and an electric vehicle connector (supplying power to the electric vehicle).

Power-Supply Cord. An assembly consisting of an attachment plug and length of flexible cord that connects the electric vehicle supply equipment (EVSE) to a receptacle.

As far as the NEC® technical committee (CMP-12) addressing output cable ampacity, there is work in progress on developing a tentative interim amendment (TIA) to add ampacity requirements to 625.17(B) which currently only indicates the acceptable types of output cables that are part of the electric vehicle supply equipment. This effort, whether successful or not, is likely to have companion proposals to revise the 625.17(C) to provide the clarification and intent of the technical committee to include specific ampacity requirements and a reference to NEC® Tables 400.5(A)(1) and 400.5(A)(2). It should be noted that the product standard for EVSE also addresses output cable ampacities.

NIST HB 44 will have provisions for inspectors to verify that the cable management system is functional during the regular inspection for public charging stations.

Gap: Cable management. There is a lack of standards or code provisions that address functional management of EV cables in public parking spaces.

Recommendation: Guidelines or standards relating to EVSE cable management should be developed.

Priority: Mid-term. **Potential Developer:** UL, NFPA, NIST. **Grid Related:** No. **Status of Progress:** Green.

Update: As noted in the text, modifications were made to Article 625 of the NEC® to define a cable management system and related to the height of the cables, and work is in progress to address output cable ampacity. NIST has been added as a developer with respect to the HB 44 work.

4.2.3.9 EVSE Maintenance

The first draft revision of NFPA 70B-2013, Recommended Practice for Electrical Equipment Maintenance, includes a new section 34.2.6 which states that EVSE can be a source of power quality problems, including harmonics from the inverters and voltage variations due to the current loading. Chapter ten is referenced for information on how to monitor and mitigate such problems.

4.2.3.10 Workplace Safety

No new information has been provided with respect to this issue.

4.3 Support Services Domain

4.3.1 Education and Training

4.3.1.1 Electric Vehicle Emergency Shut Off – High Voltage Batteries, Power Cables, Disconnect Devices; Fire Suppression, Firefighting Tactics and Personal Protective Equipment

NFPA's Fire Protection Research Foundation, in partnership with the Auto Alliance, DOE and NHTSA, created a Technical Advisory Panel to research and develop best practices for fire suppression and

firefighting tactics for incidents involving electric vehicle batteries. The results of this work were published in June 2013 in a report titled *Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results*.⁸ The report considered whether the test results and data collected would alter interim guidance provided in the NFPA *Electric Vehicle Emergency Field Guide*, 2012 edition. The report found, among other things, that standard vehicle firefighting equipment and tactics may be used for suppressing / extinguishing EV and hybrid fires. It also found that personal protective equipment (PPE) and self-contained breathing apparatus (SCBA) should be worn and utilized for all vehicle fires. In addition, the use of water does not present an electrical hazard to firefighting personnel. The report outlines possible future work to further identify and understand firefighter tactics and suppression strategies for EVs.

Partial Gap: Electric vehicle emergency shut off – high voltage batteries, power cables, disconnect devices; fire suppression, firefighting tactics and personal protective equipment. Standards / guidelines are needed so that emergency responders can safely manage emergency events involving electric vehicles.

Recommendation: Develop standards / guidelines so that emergency responders can quickly and easily recognize high voltage batteries and power cables, operate disconnect devices, avoid electrical shock hazards, and safely shut off power to an electric vehicle following an incident. Consider the need for further standardization work with respect to fire suppression, firefighting tactics, and personal protective equipment, based on the results of research underway by NFPA's Fire Protection Research Foundation in partnership with others. **Priority:** Near-term. **Potential Developer:** NFPA, SAE, ISO, IEC. **Grid Related:** No. **Status of Progress:** Green. **Update:** The roadmap version 2.0 noted that the publication of SAE J2990 largely addressed the partial gap with respect to vehicle emergency shut off. The partial gap will remain open pending possible future research and/or standardization work to further identify and understand firefighter tactics and suppression strategies for EVs.

4.3.1.2 Labeling of EVSE and Load Management Disconnects for Emergency Situations

Gap: Labeling of EVSE and load management disconnects for emergency situations. Standards are needed to address labeling of EVSE and load management disconnects for emergencies.

Recommendation: Develop standards to address graphical symbols and warning labels on EVSE as well as disconnect instructions for emergency situations. Amend NEC® Article 625 to include requirements for graphical symbols and color-coding of load management equipment and disconnects for emergency situations. **Priority:** Near-term. **Potential Developer:** UL, NEMA, NFPA, SAE, ISO, IEC. **Grid Related:** No. **Status of Progress:** Not started. **Update:** Changes to the NEC® do not address this gap. It could be

⁸ <http://avt.inl.gov/pdf/energystorage/FinalReportNFPA.pdf>

addressed in the next NEC® revision. Marking requirements provide that EVSE is for use with EVs and state whether or not ventilation is required. Nothing is stated in relation to emergency situations per se.

4.3.1.3 OEM Emergency Response Guides

No new information has been provided with respect to this issue.

4.3.1.4 Electrical Energy Stranded in an Inoperable RESS; Battery Assessment and Safe Discharge Following an Emergency Event

As noted in the roadmap version 2.0, NHTSA and Argonne National Laboratory have a project underway to develop a universal diagnostic and battery discharge system. This includes identifying diagnostic protocols, access means (connected, wireless, near field communication), and methods of diagnosing and extracting stranded energy. This project will be completed by the end of November 2014 and a report will likely be published in the Spring of 2015.

In 2014, NHTSA also has initiated projects with Sandia and Idaho National Laboratories on a dynamic diagnostic strategy. This includes performing ongoing diagnostics of the battery to determine the trend just prior to and immediately after a crash event. It uses impedance monitoring of cells / modules but still requires some method of accessing the data post-crash. Current capabilities can monitor up to a 50 volt module with a single diagnostic tool.

There has not been much progress on SAE J3009, Stranded Energy – Reporting and Extraction from Vehicle Electrochemical Storage Systems, but the committee is restarting with a new chair.

Gap: Electrical energy stranded in an inoperable RESS. Standards to enable common method assessment of RESS condition and stability, and removal of the energy stranded in an inoperable RESS, are needed to increase the safety margin to persons who may become exposed to the device in an inoperable state for various reasons and conditions during the RESS life cycle.

Recommendation: Carry out research to independently identify a solution set to the issue of electrical energy stranded in a damaged or inoperable RESS. Complete work on SAE J3009 to address a similar scope. **Priority:** Near-term. **Potential Developer:** SAE, NHTSA, Argonne NL, Sandia NL, Idaho NL. **Grid Related:** No. **Status of Progress:** Green. **Update:** As noted in the text. Sandia NL and Idaho NL have been added as potential developers.

Gap: Battery assessment and safe discharge following an emergency event. There do not appear to be standards addressing the assessment of battery stability and the need for safe discharge of EV batteries following an emergency event.

Recommendation: Standards and/or guidelines to assess battery stability and the need for safe discharge following an emergency event are needed to identify safe practices for performing such

assessment and discharge and what training, equipment and personal protective equipment may be required. The research on stranded electrical energy underway at NHTSA, Argonne NL, Sandia NL and Idaho NL, is a first step before developing such guidelines. **Priority:** Near-term. **Potential Developer:** SAE, NHTSA, Argonne NL, Sandia NL, Idaho NL, NFPA. **Grid Related:** No. **Status of Progress:** Not started. **Update:** As noted in the text. Sandia NL and Idaho NL have been added as potential developers.

4.3.1.5 Disaster Planning / Emergency Evacuations Involving Electric Vehicles

No new information has been provided with respect to this issue.

4.3.1.6 Workforce Training

General

On July 16, 2014, the DOE clean cities program issued a funding opportunity announcement⁹ that includes alternative fuel training for first responders, public safety officials, and critical service providers. Interest is in applications that will:

develop and/or deliver alternative fuel safety and technical training to emergency first responders, public safety officials, and critical service providers that have a broad impact across the alternative fuel user community. This may include training for technicians and service personnel that will be operating and maintaining AFVs; and the associated fueling/charging infrastructure and service facilities. Training may also include tow-truck operators and automotive salvage/recycling operators that are dealing with wrecked vehicles and equipment end-of-life processes.

DOE clean cities is also working on a zoning codes and ordinances website geared for municipal planners, community planning officials, and state officials.

Emergency First Responder Training

NFPA has received a Department of Homeland Security assistance to firefighter grant to develop learning modules for electric and hybrid commercial trucks, buses and medium sized delivery vehicles. NFPA will be providing that information to the responder community once the curriculum development is done.

NFPA is working to expand its first responder training to also include law enforcement and EMS, to disseminate best practices on stranded energy and high voltage batteries, and to provide free online training to the responder community.

⁹ <https://eere-exchange.energy.gov/Default.aspx#Foald334a63fc-6925-4d5a-a148-226905821333>

EVSE Installer and Inspector Training

UL offers resources related to EV infrastructure installation, including:

- An online, self-paced training program.¹⁰ The program is also offered on-site. UL maintains a list of installers who have successfully completed the course.¹¹
- A free on-demand webinar, titled “Electric Vehicle (EV) Charging Systems: Designing for Compliance to Safety and Performance Standards.”¹²

Charging Station Permitting

Partial Gap: Workforce training – charging station permitting. From a training perspective, there may be a need to assemble and promote a “Code Official Toolkit” related to EVSE permitting.

Recommendation: Develop a Code Official Toolkit on EVSE permitting that includes, among other things, the DOE permit template, EVSE 101 video, and an FAQ document for code officials that explains, for example, the importance of safe and code-compliant EV charging station installation requirements, and relevant safety training programs. Consider creating a brief article that would highlight this issue and the Toolkit as resources to run in appropriate association newsletters to increase awareness of resources available to installers, inspectors and other authorities having jurisdiction. **Priority:** Near-term. **Potential Developer:** DOE, ICC, NECA, IAEI, NFPA. **Grid Related:** No. **Status of Progress:** Yellow. **Update:** No specific update has been provided with respect to this gap, other than what is noted in the text.

College and University Programs

Partial Gap: Workforce training – college and university programs. Identified higher education programs related to electric vehicles do not appear to cover some issues that relate to charging infrastructure development such as land use, community planning, and architecture.

Recommendation: Develop higher education programs focused on electric vehicle charging infrastructure development from the standpoint of land use, community planning and architecture. **Priority:** Mid-term. **Potential Developer:** Colleges and Universities. **Grid Related:** No. **Status of Progress:** Unknown. **Update:** The earlier mentioned DOE clean cities solicitation notes that projects may include curriculum development and resources for utilization at community colleges, technical schools, etc.

¹⁰ <http://lms.ulknowledgeservices.com/catalog/display.resource.aspx?resourceid=303396>

¹¹ [http://site.ul.com/global/eng/pages/offerings/industries/powerandcontrols/electricvehicle/evinstallers/.](http://site.ul.com/global/eng/pages/offerings/industries/powerandcontrols/electricvehicle/evinstallers/)

¹² <http://lms.ulknowledgeservices.com/catalog/display.resource.aspx?resourceid=410508>

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5. Summary of Gap Analysis

Priority: Near-term (0-2 years); Mid-term (2-5 years); Long-term (5+ years).

Status of Progress on Gaps: Closed (completed), Green (moving forward), Yellow (delayed in progressing), Red (at a standstill), Not started, Unknown, or New Gap.

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
1.	Terminology	4.1 / 13	Terminology. There is a need for consistency with respect to electric vehicle terminology	Complete work to revise SAE J1715. Update: As noted, SAE J1715 has been divided into two parts which have been published.	Mid-term	SAE, ISO	No	Green
2.	Power Rating Methods	4.1.1.1 / 13	Power rating methods. Standards for electric vehicle power rating methods are still in development.	Complete work to develop SAE J2907 and J2908. Update: It was noted in roadmap version 2.0 that standards for electric vehicle power rating methods had been canceled because of resource issues and would be re-opened later. As noted, work on the power rating method standards SAE J2907 and J2908 has been restarted.	Mid-term	SAE	No	Green
3.	Functional Safety in the Charging System	4.1.1.2 / 14	Functional safety in the charging system. Potential faults in the charging system, both on-board and off-board, are the subject of NHTSA sponsored research and may need to be addressed in future rulemaking and/or standardization.	Future NHTSA rulemaking and/or revisions to SAE J2929 should consider the results of the DOT/NHTSA-funded SAE Cooperative Research Project with respect to fault events in the charging system which could lead to overcharging. Update: As noted in the text, work is underway in the CRP to address this issue.	Near-term	NHTSA, SAE	No	Green
4.	Delayed Battery Overheating Events	4.1.1.2 / 14	Delayed battery overheating events. The issue of delayed battery overheating needs to be addressed.	Address the issue of delayed battery overheating events in future rulemaking and/or revisions of SAE J2929 based on the results of the DOT/NHTSA-funded SAE Cooperative Research Project. Update: Work is underway in the CRP to address this issue.	Near-term	NHTSA, SAE	No	Green
5.	Battery Testing - Performance and Durability	4.1.1.3 / 15	Battery performance parameters and durability testing. There is a need for further work on EV battery performance parameters and environmental durability test requirements.	Complete work on SAE J1798 and if possible consider harmonization with ISO 12405-2. Update: No change. There is not a lot of progress to date on SAE J1798.	Mid-term	SAE, ISO	No	Yellow

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
6.	Battery Storage	4.1.1.4 / 15	Safe storage of lithium-ion batteries. At present, there are no published standards addressing the safe storage of lithium-ion batteries specifically, whether at warehouses, repair garages, recovered vehicle storage lots, auto salvage yards, or battery exchange locations.	A standard on safe storage practices for EV batteries must be developed, addressing both new and waste batteries and the wide range of storage situations that may exist, including when the batteries are separated from their host vehicle. <u>Update:</u> Work by the NFPA Fire Protection Research Foundation and IEC/TC 69 is noted in the text.	Near-term	SAE, NFPA, ICC, IEC/TC 69	No	Green
7.	Battery Packaging, Transport and Handling	4.1.1.4 / 16	Packaging and transport of waste batteries. Current standards and regulations do not adequately cover transportation aspects of <i>waste</i> batteries (damaged, aged, sent for repair, end-of-life) in terms of packaging, loading limitations, combination with other dangerous goods on same transport, etc.	There is a need for a harmonized approach toward communication, labeling, packaging restrictions, and criteria for determining when a battery is waste. <u>Update:</u> With the approval of new UN regulations, this gap is now closed.	Near-term	UN SCOE on the Transport of Dangerous Goods, ISO/TC 22/SC21, SAE or UL	No	CLOSED
8.	Battery Packaging, Transport and Handling	4.1.1.4 / 16	Packaging and transport of batteries to workshops or battery swapping stations. Unloading a battery in a battery swapping station is extremely challenging with the original packaging used for dangerous goods transportation. There is a need for standards for intermediate packaging to cover transport to battery swapping stations.	Intermediate packaging is required between the import location of the battery and battery swapping stations and needs to be standardized around geometry, safety and matching to UN packaging requirements. <u>Update:</u> IEC 62840, Parts 1 and 2, under development, may deal with aspects of this issue.	Mid-term	ISO/TC 22/SC21, IEC/TC 69, SAE or UL	No	Unknown
9.	Battery Recycling	4.1.1.5 / 17	Battery recycling. Standards are needed in relation to EV (li-ion) battery recycling.	Complete work on SAE J2974 and J2984. EV (li-ion) battery recycling standards are desirable to address the calculation method toward recycling efficiency and recovery rates based on an agreed unit (possibly weight) and/or life-cycle assessment tools, including energy recovery. <u>Update:</u> Relevant work by SAE is noted in the text.	Near-term	SAE, IEC	No	Green
10.	Battery Secondary Uses	4.1.1.6 / 17	Battery secondary uses. There is a need for standards to address battery second life applications for grid storage and other uses.	Explore the development of standards for battery secondary uses, addressing such issues as safety and performance testing for intended applications, grid connection/communication interfaces, identification of parts/components that can be removed from the pack without destroying it, etc. <u>Update:</u> UL work is noted in the text. No new information was provided on SAE activity.	Mid-term	SAE, UL	No	Green
11.	Crash Tests/ Safety	4.1.1.7 / 17	Crash Test Lab Safety Guidelines. There is a need for laboratory guidance and instruction to help mitigate the risks to personnel, equipment, and	Complete work to develop an Information Report (SAE J3040) that can be readily available to any crash test laboratory conducting, or planning to conduct,	Near-term	SAE	No	NEW Gap / Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
			facilities that may exist in the event of catastrophic failure of the battery system.	full scale crash tests on EVs/HEVs.				
12.	Internal High Voltage Cables, On-Board Wiring, Component Ratings and Charging Accessories	4.1.2.1 / 18	No Gap	N/A	N/A	N/A	No	N/A
13.	Vehicle Diagnostics - Emissions	4.1.2.2 / 18	No Gap	N/A	N/A	N/A	No	N/A
14.	Audible Warning Systems	4.1.2.3 / 18	Audible warning systems. Creation of the NHTSA safety standard and compliance with it will effectively close any gap with respect to audible warning systems for electric vehicles sold in the U.S. market. Ongoing standards work in SAE and ISO, and in WP.29 with respect to the development of a Global Technical Regulation would provide a means for international harmonization around this issue.	Continue work on safety standards to address EV sound emission and measurement. <u>Update:</u> Work continues as noted in the text.	Near-term	SAE, ISO, NHTSA, WP.29	No	Green
15.	Graphical Symbols	4.1.3.1 / 19	Graphical symbols for electric vehicles. Standards for graphical symbols for electric vehicles are needed to communicate important information to the driver such as state of charge, failure or normal system operation which can be understood regardless of the driver's language.	Develop EV graphical symbols standards to communicate information to the driver. <u>Update:</u> None provided	Long-term	SAE, NHTSA, ISO, IEC	No	Not started
16.	Telematics – Driver Distraction	4.1.3.2 / 19	No Gap	N/A	N/A	N/A	No	N/A
17.	Fuel Efficiency, Emissions, and Labeling	4.1.3.3 / 19	No Gap	N/A	N/A	N/A	No	N/A
18.	Communications in support of wireless power transfer	4.2.1.1 / 20	Coordination of wireless charging communication standards. Automotive manufacturers do not want to support three separate activities dealing with the same issue. An initiative is underway to understand how the work can be done once or divided between ISO, IEC and SAE. There is no clear cut technology solution right now.	Organizations developing standards, guidelines or use cases related to wireless charging communications should coordinate their activities in order to avoid duplication of effort, assure alignment, and maximize efficiency.	Near-term	SAE, ISO, IEC	Yes	NEW Gap / Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
19.	Wireless Charging	4.2.1.1 / 20	Wireless charging. Standards and guidelines for wireless charging are still in development.	Complete work on standards and guidelines for wireless charging as described above in the text. <i>Update:</i> The text has been updated to note work taking place, including communications and EMC aspects. The recommendation statement has been made general with references to specific standards removed. ISO has been added as a developer.	Near-term	SAE, UL, IEEE, ISO. IEC	Yes	Green
20.	Battery Swapping	4.2.1.2 / 22	Battery swapping – safety. Currently, there is a need to define minimum requirements for the safe operation of battery swapping stations, as mass deployment of battery swapping systems is currently underway in several countries around the world.	Complete work on IEC 62840 to define minimum requirements for the safe operation of battery swapping stations, and on SAE J3073. <i>Update:</i> The text has been updated to note that the standard is in two parts. Priority level has been changed from near-term to mid-term in light of this technology’s relevance to the U.S. market. SAE has been added as a potential developer given new work on battery cooling.	Mid-term	IEC/TC 69, SAE	No	Green
21.	Battery Swapping	4.2.1.2 / 22	Battery swapping – interoperability. Standards are needed to help facilitate the penetration of battery swapping in the market. Issues to be addressed related to removable batteries include electrical interfaces, cooling integration, data transfer integration, and common mechanical and dimensional interfaces.	Define interoperability standards related to battery swapping. <i>Update:</i> Some of the mentioned aspects of interoperability may be addressed in the IEC 62840 work that is taking place. Priority level has been changed from near-term to mid-term in light of this technology’s relevance to the U.S. market. SAE has been added as a potential developer given new work on battery cooling.	Mid-term	IEC/TC 69, SAE	No	Green
22.	Power Quality	4.2.1.3 / 22	Power quality. SAE J2894/1 was published in December 2011. At the time of publication of roadmap version 2.0, SAE J2894, Part 2, was still in development.	Complete work on SAE J2894, Part 2. <i>Update:</i> The gap statement has been updated to indicate that SAE J2894/2 was still in development when version 2.0 of this roadmap was published. Once it is published, the partial gap on power quality identified in version 2.0 of this roadmap will be closed.	Near-term	SAE	Yes	Green
23.	EVSE Charging Levels/Modes	4.2.1.3 / 23	EVSE charging levels. At the time of release of version 1.0 of this roadmap, the levels for DC charging within SAE J1772™ had yet to be finalized.	Complete work to establish DC charging levels within SAE J1772™. <i>Update:</i> No change. This gap was deemed closed at the time of publication of version 2.0 of the roadmap.	Near-term	SAE	Yes	CLOSED

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
24.	EV Supply Equipment and Charging Systems	4.2.1.3 / 23	Off-board charging station and portable EV cord set safety within North America. At the time of release of version 1.0 of this roadmap, the harmonization of equipment safety standards within North America based on the UL 2594 standard was still underway	Finish North American harmonization effort based on UL 2594 addressing off-board charging station and portable EV cord set safety. Update: This gap was deemed closed at the time of publication of version 2.0 of the roadmap, with the publication of the North American tri-national standard based on UL 2594 in February 2013. Since that time, a Phase 2 harmonization effort has begun in CANENA to address additional technical items. There will also be a need to address NEC® 2014 technical issues in the tri-national standard.	Near-term	UL, CSA, ANCE (Mexico), NEMA	Yes	CLOSED
25.	EV Supply Equipment and Charging Systems	4.2.1.3 / 23	Off-board charger safety within North America. Harmonization of equipment safety standards within North America is needed.	There appears to be a need to harmonize the safety requirements for off-board chargers with the U.S., Canada, and Mexico. Update: No change.	Mid-term	UL, CSA, ANCE (Mexico), NEMA	Yes	Not started
26.	EV Supply Equipment and Charging Systems	4.2.1.3 / 23	Off-board charger, off-board charging station and portable EV cord set safety globally. There are some differences between the IEC 61851 series of standards and the North American standards. While not a gap per se with respect to the U.S. market, the use of infrastructure equipment and the means to mitigate risks would prove beneficial to manufacturers if harmonization was completed.	Work to harmonize the IEC 61851 series standards and the North American standards. Update: No official harmonization effort is taking place but there are informal discussions about aligning the standards when opportunities arise.	Mid-term	UL, IEC	Yes	Not started
27.	EV Couplers: Safety and Harmonization Efforts	4.2.1.3 / 24	EV coupler safety within North America. At the time of publication of version 1.0 of this roadmap, harmonization of EV coupler safety standards within North America based on the UL 2251 standard was still underway.	Finish efforts to harmonize standards addressing EV coupler safety within North America. Update: This gap was deemed closed at the time of publication of version 2.0 of the roadmap, with the publication of the North American tri-national standard based on UL 2251 in February 2013. Since that time, a Phase 2 harmonization effort has begun in CANENA to address additional technical items.	Near-term	UL, CSA, ANCE (Mexico), NEMA	Yes	CLOSED
28.	EV Couplers: Safety and Harmonization Efforts	4.2.1.3 / 24	EV coupler safety globally. There are some differences between the IEC 62196 series standards and the North American EV coupler safety standards. While not a gap per se with respect to the U.S. market, global harmonization would help to reduce costs for vehicle manufacturers.	Work to harmonize the IEC 62196 series standards and the North American EV coupler safety standards. Update: No official harmonization effort is taking place but there are informal discussions about aligning the standards when opportunities arise.	Mid-term	UL, IEC	Yes	Not started
29.	EV Couplers: Interoperability with EVSE and Harmonization	4.2.1.3 / 25	EV coupler interoperability with EVSE globally. Different coupler configurations are used in different parts of the world. Global harmonization would help to reduce costs for manufacturers. At	Incorporate the new SAE J1772™ combination coupler into IEC 62196-3. Build out the charging infrastructure to accommodate variations in EV coupler configurations for particular markets as	Near-term	SAE, IEC, ISO, CHAdeMO, vehicle and	Yes	Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
	Efforts		the time of release of version 1.0 of this roadmap, the revision of SAE J1772™ was still in progress; it has now been published.	necessary, in particular with respect to DC charging. Update: The combo coupler configuration is included in IEC 62916 part 3. The gap statement and recommendation have not been modified. However, the text has been updated to note the differences between the SAE and IEC standards in terms of allowing AC and DC charging to occur on the same contact pins. ISO has been added as a developer.		charging station manufacturers		
30.	EV Couplers: Interoperability with EVSE – Conformance Programs	4.2.1.3 / 26	Conformance programs for EV coupler interoperability within the U.S. market. A program(s) is needed for the U.S. market to verify compatibility between the EV coupler, the infrastructure and the vehicle.	Complete work on SAE J2953. Establish a program(s) to verify interoperability between infrastructure equipment, including the vehicle connector, and all vehicles that follow the SAE J1772™ protocol. Update: The gap statement is largely addressed with the publication of the two parts of SAE J2953. No information has been provided on the status of the UL verification program.	Near-term	SAE, UL	Yes	Green
31.	Electromagnetic Compatibility (EMC)	4.2.1.4 / 26	Electromagnetic compatibility (EMC). Standards to address EMC issues related to electric vehicle charging are still in development.	Complete work on IEC 61851-21, Parts 1 and 2, and SAE J2954 to address EMC issues related to electric vehicle charging. Update: Work on IEC 61851-21, parts 1 and 2, and SAE J2954 continues.	Near-term	IEC/TC 69, SAE	Yes	Green
32.	Vehicle as Supply	4.2.1.5 / 26	Vehicle as supply / reverse power flow. The version 2.0 roadmap gap stated that differences exist between the DER model defined by SAE J2836/3™, IEC/TR 61850-90-7, IEC/TR 61850-90-8, and SEP 2.0.	The version 2.0 roadmap recommendation was to harmonize the information model for an EV as a DER between SAE J2836/3™, IEC/TR 61850-90-8, and SEP 2.0. Update: The roadmap version 2.0 text has been substantially revised. SAE J2836/3™ functionality aligns with SEP 2.0, so that aspect of the gap is closed. SEP 2.0 has been published by the IEEE which has been added as a developer (ZigBee Alliance and the HomePlug Powerline Alliance had transferred SEP 2.0 to IEEE.) SAE worked with EPRI to align Version 3 of their Common Functions for Smart Inverters report with SAE J2836/3™. IEC is using the EPRI V3 report to directly update the actual DER model contained in IEC 61850-7-420 rather than flow it using an interim technical report, such as IEC/TR 61850-90-8 or 90-9. This part of the gap will be closed once IEC 61850-7-420 is published.	Near-term	SAE, IEC/TC 57	Yes	Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
33.	Vehicle as Supply	4.2.1.5 / 26	Certification Standards for Mobile inverters. UL 1741 is the safety standard for inverters which connect to the grid. It is not appropriate for distributed inverter systems within an EV. A new standard is needed for on-board inverter systems. UL 2594, Electric Vehicle Supply Equipment, is the safety standard for an EVSE that connects to an EV with an on-board charger but it does not cover the unique requirements for interconnection with an EV with an on-board inverter.	Create SAE J3072 which can be used to ensure that an EV with an on-board inverter system can be safely interconnected to the electric power system. Modify UL 9741 to serve as the standard for an EVSE which is interoperable with an EV inverter system which conforms to SAE J3072.	Near-term	SAE and UL	Yes	NEW gap / Green
34.	Vehicle as Supply	4.2.1.5 / 26	Mobile inverters: interconnection agreements. There are no simple utility procedures to approve an EV with an on-board inverter to interconnect to the grid.	Coordinate an approach with utilities and federal and state government agencies on how an EV with an on-board inverter can be approved to discharge at a specific EVSE location.	Near-term	key utilities with V2G interest, Federal Energy Regulatory Commission, DOE, State PUCs, and others	Yes	NEW gap / Red
35.	Use of Alternative Power Sources	4.2.1.6 / 30	Use of alternative power sources. The National Electrical Code® does not specifically address the integration of the EV and EVSE with a facility high voltage DC power distribution system for either charging or reverse power flow.	Develop NEC® requirements for high voltage DC power distribution systems and the integration of distributed energy resources and DC loads with the system. <u>Update:</u> This remains an open issue.	Near-term	NFPA	Yes	Green
36.	Locating and Using Public Charging Stations (EVSE)	4.2.2.2 / 32	Locating and reserving a public charging station. There is a need for a messaging standard to permit EV drivers to locate a public charging spot and reserve its use in advance.	Develop a messaging standard to permit EV drivers to universally locate and reserve a public charging spot. <u>Update:</u> The text has been updated to note recent developments. eMI ³ and OCA have been added as potential developers.	Mid-term	SAE, ISO/IEC JWG, NEMA, eMI ³ , OCA	Yes	Green
37.	Roaming	4.2.2.2 / 32	Charging of roaming EVs between EVSPs. There is a need to permit roaming EVs to charge at spots affiliated with a different EVSP.	Develop back end requirements as well as an interface standard that supports charging of roaming EVs between EVSPs. <u>Update:</u> The text has been updated to note recent developments. eMI ³ has been added as a potential developer.	Near-term	NEMA, IEC, eMI ³	Yes	Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
38.	Access Control	4.2.2.2 / 32	Access control at charging stations. There is a need to develop data definition and messaging standards for communicating access control at charging stations.	Develop data definition and messaging standards for communicating access control at charging stations. <i><u>Update:</u></i> As noted in roadmap version 2.0, the NEMA 5EVSE Network Roaming WG looked at this roadmap version 1.0 gap, decided that offline access control lists were a low priority, and deferred action on offline access control to a later phase of work. Priority changed to mid-term.	Mid-term	NEMA	Yes	Yellow
39.	Communication of Standardized EV Sub-metering Data	4.2.2.3 / 37	Communication of standardized EV sub-metering data. Standards are needed for communication of EV sub-metering data between third parties and service providers.	Complete Green Button Sub-metering Profile of ESPI for communication of standardized EV sub-metering data, for example, between a third party and a billing agent (e.g., utility). <i><u>Update:</u></i> No change. ESPI sub-metering profile of Green Button Connect My Data still in progress.	Near-term	OpenADE/NAESB	Yes	Green
40.	Standardization of EV Sub-meters	4.2.2.3/ 37	Standardization of EV sub-meters. Standards for EV sub-meters, including embedded sub-meters, need to be completed to address performance, security/privacy, access, and data aspects.	Develop standards or guidelines related to the functionality and measurement characteristics of the new types of sub-meters that are coming out for EVs, including embedded sub-meters in the EVSE or EV. Such standards should address different form factors, capabilities, installation, and certification. <i><u>Update:</u></i> Work is proceeding as described in the text. SGIP PAP-22 WG was added as a potential developer.	Near-term	NEMA, USNWG EVF&S, , SGIP PAP-22 WG	Yes	Green
41.	Coordination of EV Sub-metering Activities	4.2.2.3 / 37	Coordination of EV sub-metering activities. Various existing activities (NEMA, USNWG EVF&S, SGIP PAP-22) need to be coordinated as much as possible.	Organizations developing standards, guidelines or use cases related to EV sub-metering should coordinate their activities in order to avoid duplication of effort, assure alignment, and maximize efficiency. <i><u>Update:</u></i> Work is being coordinated among NEMA, USNWG EVF&S, and SGIP PAP-22 WG. Note: The reference to SGIP V2G DEWG has been changed to SGIP PAP-22 WG.	Near-term	NEMA, USNWG EVF&S, SGIP PAP-22 WG	Yes	Green
42.	Cyber Security and Data Privacy	4.2.2.4 / 39	Cyber security and data privacy. There is a need for guidelines and standards to address cyber security and data privacy concerns associated with PEVs and smart grid communications.	Complete work to develop SAE J2931/7, and to revise ISO/IEC 15118-1 and NISTIR 7628, volume 2 <i><u>Update:</u></i> As noted in the text.	Near-term	SAE, ISO/IEC JWG, NIST	Yes	Green
43.	Customer to PEV Communications	4.2.2.5 / 40	Customer to PEV communications. There is a need to develop use cases related to customer vehicle information including non-utility aggregation control in order to assess the existing functionalities, and to determine any missing requirements within the context of existing	Complete work to develop SAE J2836/5 TM . <i><u>Update:</u></i> As noted in the text. This section has been re-named Customer to PEV communications. The gap statement has been slightly modified.	Near-term	SAE	Yes	Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
			standards, Energy Service Provider business requirements, and telematics networks to support smart grid load management.					
44.	Site Assessment / Power Capacity Assessment	4.2.3.1 / 40	No Gap	N/A	N/A	N/A	Yes	N/A
45.	EV Charging – Signage and Parking	4.2.3.2 / 41	No Gap	N/A	N/A	N/A	Yes	N/A
46.	Charging Station Permitting	4.2.3.3 / 41	No Gap	N/A	N/A	N/A	Yes	N/A
47.	Environmental and Use Conditions	4.2.3.4 / 41	No Gap	N/A	N/A	N/A	No	N/A
48.	Ventilation - Multiple Charging Vehicles	4.2.3.5 / 41	No Gap	N/A	N/A	N/A	No	N/A
49.	Guarding of EVSE	4.2.3.6 / 41	Guarding of EVSE. There is a lack of standards that address charging station design with respect to physical and security protection of the equipment.	Guidelines or standards relating to guarding of EVSE should be developed. Update: The roadmap version 2.0 notes that NFPA 730, Guide to Premises Security, Annex E discusses the placement / design of bollards. In addition, section 110 of the (NEC®) addresses protection of electrical equipment generally. Where there appears to be a partial gap is a lack of guidance on protection of EVSE specifically. This could be developed in the 2017 version of the (NEC®). Public input on the NEC® closes 7 November 2014. The NEC® panel will meet in January 2015.	Mid-term	NFPA	No	Not started
50.	Accessibility for Persons with Disabilities to EVSE	4.2.3.7 / 42	Accessibility for persons with disabilities to EVSE. There is a lack of standards that address charging station design with respect to accessibility for persons with disabilities to EVSE.	Guidelines or standards relating to accessibility for persons with disabilities to EVSE should be developed. Update: In June 2013, proposals were made to the ICC A117.1 committee for technical criteria on how to make an EV charging station accessible. They were approved by the committee and received no public comment, so they will be in the next edition of the standard. Proposed scoping provisions (i.e., what,	Mid-term	ICC (A117.1 and IBC®, IgCC™ or IZC®)	No	Green

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
				where and how many) for the International Building Code may be submitted to ICC by Jan. 5, 2015.				
51.	Cable Management	4.2.3.8 / 42	Cable management. There is a lack of standards or code provisions that address functional management of EV cables in public parking spaces.	Guidelines or standards relating to EVSE cable management should be developed. <i>Update:</i> As noted in the text, modifications were made to Article 625 of the NEC® to define a cable management system and related to the height of the cables, and work is in progress to address output cable ampacity. NIST has been added as a developer with respect to the HB 44 work.	Mid-term	UL, NFPA, NIST	No	Green
52.	EVSE Maintenance	4.2.3.9 / 43	No Gap	N/A	N/A	N/A	No	N/A
53.	Workplace Safety	4.2.3.10 / 43	No Gap	N/A	N/A	N/A	No	N/A
54.	Electric Vehicle Emergency Shut Off – High Voltage Batteries, Power Cables, Disconnect Devices; Fire Suppression, Firefighting Tactics and Personal Protective Equipment	4.3.1.1 / 43	Electric vehicle emergency shut off – high voltage batteries, power cables, disconnect devices; fire suppression, firefighting tactics and personal protective equipment. Standards / guidelines are needed so that emergency responders can safely manage emergency events involving electric vehicles.	Develop standards / guidelines so that emergency responders can quickly and easily recognize high voltage batteries and power cables, operate disconnect devices, avoid electrical shock hazards, and safely shut off power to an electric vehicle following an incident. Consider the need for further standardization work with respect to fire suppression, firefighting tactics, and personal protective equipment, based on the results of research underway by NFPA’s Fire Protection Research Foundation in partnership with others. <i>Update:</i> The roadmap version 2.0 noted that the publication of SAE J2990 largely addressed the partial gap with respect to vehicle emergency shut off. The partial gap will remain open pending possible future research and/or standardization work to further identify and understand firefighter tactics and suppression strategies for EVs.	Near-term	NFPA, SAE, ISO, IEC	No	Green
55.	Labeling of EVSE and Load Management Disconnects for Emergency Situations	4.3.1.2 / 44	Labeling of EVSE and load management disconnects for emergency situations. Standards are needed to address labeling of EVSE and load management disconnects for emergencies.	Develop standards to address graphical symbols and warning labels on EVSE as well as disconnect instructions for emergency situations. Amend NEC® Article 625 to include requirements for graphical symbols and color-coding of load management equipment and disconnects for emergency situations.	Near-term	UL, NEMA, NFPA, SAE, ISO, IEC	No	Not started

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
				Update: Changes to the NEC® do not address this gap. It could be addressed in the next NEC® revision. Marking requirements provide that EVSE is for use with EVs and state whether or not ventilation is required. Nothing is stated in relation to emergency situations per se.				
56.	OEM Emergency Response Guides	4.3.1.3 / 45	No Gap	N/A	N/A	N/A	No	N/A
57.	Electrical Energy Stranded in an inoperable RESS	4.3.1.4 / 45	Electrical energy stranded in an inoperable RESS. Standards to enable common method assessment of RESS condition and stability, and removal of the energy stranded in an inoperable RESS, are needed to increase the safety margin to persons who may become exposed to the device in an inoperable state for various reasons and conditions during the RESS life cycle.	Carry out research to independently identify a solution set to the issue of electrical energy stranded in a damaged or inoperable RESS. Complete work on SAE J3009 to address a similar scope. Update: As noted in the text. Sandia NL and Idaho NL have been added as potential developers.	Near-term	SAE, NHTSA, Argonne NL, Sandia NL, Idaho NL	No	Green
58.	Battery Assessment and Safe Discharge Following an Emergency Event	4.3.1.4 / 45	Battery assessment and safe discharge following an emergency event. There do not appear to be standards addressing the assessment of battery stability and the need for safe discharge of EV batteries following an emergency event.	Standards and/or guidelines to assess battery stability and the need for safe discharge following an emergency event are needed to identify safe practices for performing such assessment and discharge and what training, equipment and personal protective equipment may be required. The research on stranded electrical energy underway at NHTSA, Argonne NL, Sandia NL and Idaho NL, is a first step before developing such guidelines. Update: As noted in the text. Sandia NL and Idaho NL have been added as potential developers.	Near-term	SAE, NHTSA, Argonne NL, Sandia NL, Idaho NL, NFPA	No	Not started
59.	Disaster Planning / Emergency Evacuations Involving Electric Vehicles	4.3.1.5 / 46	No Gap	N/A	N/A	N/A	No	N/A
60.	Workforce Training – Charging Station Permitting	4.3.1.6 / 46	Workforce training – charging station permitting. From a training perspective, there may be a need to assemble and promote a “Code Official Toolkit” related to EVSE permitting.	Develop a Code Official Toolkit on EVSE permitting that includes, among other things, the DOE permit template, EVSE 101 video, and an FAQ document for code officials that explains, for example, the importance of safe and code-compliant EV charging station installation requirements, and relevant safety training programs. Consider creating a brief article that would highlight this issue and the Toolkit as resources to run in appropriate association newsletters to increase awareness of resources	Near-term	DOE, ICC, NECA, IAEI, NFPA	No	Yellow

	Roadmap Issue	Section / page	Gap	Recommendation	Priority	Potential Developer	Grid Related	Status of Progress
				available to installers, inspectors and other authorities having jurisdiction. <i><u>Update:</u></i> No specific update has been provided with respect to this gap, other than what is noted in the text.				
61.	Workforce Training – College and University Programs	4.3.1.6 / 46	Workforce training – college and university programs. Identified higher education programs related to electric vehicles do not appear to cover some issues that relate to charging infrastructure development such as land use, community planning, and architecture.	Develop higher education programs focused on electric vehicle charging infrastructure development from the standpoint of land use, community planning and architecture. <i><u>Update:</u></i> The earlier mentioned DOE clean cities solicitation notes that projects may include curriculum development and resources for utilization at community colleges, technical schools, etc.	Mid-term	Colleges and universities	No	Unknown

STANDARDIZATION ROADMAP
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